

GREEN RIVER GAME LAND AQUATIC INVENTORY

by

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GREEN RIVER GAME LAND AQUATIC INVENTORY

Introduction

Green River Game Land lies along the eastern slope of the Blue Ridge escarpment in southwestern North Carolina. Located approximately 6 miles southeast of Hendersonville, the game land spans across parts of Henderson, Polk, and Rutherford counties. The approximately 21,000-acre area of land is comprised of 1 main tract of land crossing the Henderson-Polk county line, and numerous tracts of land along the Polk-Rutherford county line. The game land lies entirely within the Broad River Basin with the western portion bordering the French Broad River Basin. The Broad River Basin consists of 1,513 square miles of land area with 1,450 stream miles in this river basin. It flows through Hickory Nut Gorge, with its scenic boulder gardens, down to Lake Lure. The French Broad River Basin is 2,829 square miles in area with the second largest number of stream miles – 4,113. This basin is characterized by mountainous topography, with the highest point east of the Mississippi – Mount Mitchell – within its watershed. This characteristic makes the French Broad a favorite for whitewater rafting, canoeing, and trout fishing enthusiasts. The major waterways associated with Green River Game Land include the Green River and its tributaries, and the Broad River and its forks and tributaries. In addition, many waterways that drain into the French Broad River lie within a few miles of the game land. The waterways in this region tend to vary from piedmont-like to mountain-like, with the larger streams tending towards the former and the smaller streams tending towards the latter.

The North Carolina Wildlife Resources Commission (NCWRC) made its initial acquisition of Green River Game Land in 1953 and 1954 through purchases of many small tracts of land from private landowners. Over the years, additional tracts of land have been purchased bringing the state-owned portion of the game land to approximately 12,000 acres. Additional private lands increase this total to approximately 21,000 acres (for purposes of the report, we used the figure from the 1998-99 game lands book, which encompassed 18,027 acres). The mountainous terrain of the game land ranges in elevation from 900 feet to 2,800 feet and is mostly forested. The dominant forest type is upland oak/hickory, with some cove hardwoods and pine. The management objectives of the NCWRC for Green River Game Land include: 1) providing habitat conditions that maintain or improve the viability of native plant and animal communities, 2) providing hunting, fishing, and trapping opportunities, 3) providing a sustained yield of forest products, and 4) providing opportunities for non-consumptive uses of the game land. White-tailed deer and wild turkey are the 2 primary big game species on the game land. The property also has the potential to serve as a black bear sanctuary and supports populations of small game and furbearer species, such as gray squirrel, cottontail rabbit, ruffed grouse, woodcock, raccoon, red and gray fox, and bobcat. In addition, the game land includes numerous rivers, streams, and ponds that provide fishing opportunities, as well as habitat for nongame species, such as song birds, small mammals, and reptiles. This area also provides habitat for the timber rattlesnake, which was recently proposed state-listed special concern. Given the diverse management objectives of the NCWRC, Green River Game Land attracts a variety of user groups for the purpose of hunting, fishing, bird watching, hiking, and other outdoor activities.

Land use impact in the areas surrounding Green River Game Land appears to be limited given the amount of undisturbed area. A visual survey of the area reveals scattered localities of active

crop and pasture lands with some logging. Overall, the area adjacent to Green River Game Land is undeveloped, but urbanization does have its effects, primarily in the Hendersonville area.

The objective of this project was to survey Green River Game Land for aquatic species, including freshwater mussels, sphaeriid clams, aquatic snails, crayfishes, and fishes. Our goals were to determine species presence, distribution, relative abundance, and relative health. The inventory included waterways in and associated with the Green River Game Land within Henderson, Polk, and Rutherford counties, North Carolina. Figure 1 and Table 1 detail the localities of all sites surveyed. The following sections provide results of the aquatic inventory for each of the taxa mentioned above. For purposes of this report, *Corbicula fluminea* (Asian clam) was grouped with the sphaeriid clams even though the 2 taxa belong to different families. It also should be noted that any plus or minus symbols listed after road numbers in the following tables represent whether we surveyed downstream or upstream, respectively.

Acknowledgements

We would like to thank the following people, without whose assistance this project would not have been possible: John M. Alderman (NCWRC) for reviewing and editing the report; Chris McGrath, Scott S. Marsh, Rebecca R. McAllister, and Todd D. Ewing (all NCWRC) for assisting with the survey; Dean M. Simon (NCWRC) for providing information and access points regarding the game land; Dr. John E. Cooper, Dr. Arthur E. Bogan, and Dr. Wayne C. Starnes, Gabriela M. Hogue, Dr. Morgan E. Raney, and Lynn Fullbright from the NC State Museum of Natural Sciences for providing assistance with identifications of crayfishes, mollusks, and fishes, respectively; Dr. Gerald L. Mackie from the University of Guelph, Ontario, Canada, for providing assistance with sphaeriid identifications. We also would like to thank the landowners and residents of Henderson, Polk, and Rutherford counties, North Carolina, who allowed us to work on their property and showed an interest in their local natural history.

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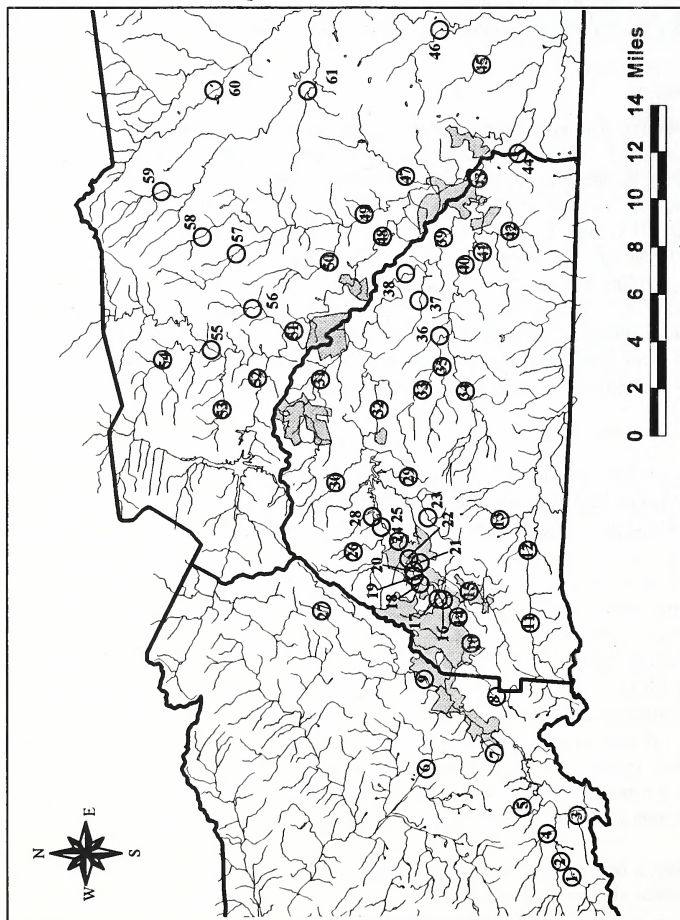


Figure 1. Map of sites surveyed during the aquatic inventory of the Green River Game Land in Henderson (1), Polk (2), and Rutherford (3) counties, North Carolina, 1999. The location of the game land within counties, and the location of the counties within the state of North Carolina, are shown to the right.

Table 1. Map numbers, corresponding sites surveyed, and survey effort (person-hours/electroshock seconds) for the Green River Game Land aquatic inventory (see Figure 1).

<u>Map #</u>	<u>Site Number(s)</u>	<u>Survey Effort</u>
1	990921.1btw, 991012.2btw	1.5/409
2	990921.2btw, 991012.3btw	1.25/356
3	990921.3btw	1.25
4	990915.2btw, 991012.4btw	1.5/139
5	990915.3btw	1.0
6	990915.1btw, 991012.1btw	1.5/280
7	990915.4btw	1.0
8	990915.5btw	1.0
9	990922.6btw, 991027.1btw	1.0/433
10	990811.1btw	7.5/815
11	990921.4btw	2.0
12	990921.5btw, 991012.5btw	2.0/444
13	990921.6btw	1.25
14	990811.2btw	6.0/506
15	990810.2btw, 990813.1btw	3.25
16	990811.3btw	2.5/372
17	990812.3btw	0.75
18	990812.2btw	1.0
19	990812.1btw	3.75
20	990901.1btw, 991027.2btw	2.0/339
21	990901.2btw	2.0
22	990901.3btw	0.5
23	990813.2btw, 991027.3btw	2.25/174
24	990901.4btw	0.25
25	990901.5btw	0.25
26	990922.2btw	0.5
27	990922.5btw	0.75
28	990901.6btw	0.5
29	990813.3btw	0.25
30	990922.1btw	0.75
31	990909.5btw, 991027.4btw	1.75/201
32	990813.4btw, 990923.4btw	3.0/561
33	990909.3btw	0.75
34	990909.1btw, 991026.4btw	1.75/227
35	990909.2btw	0.75
36	990909.4btw, 991026.3btw	1.0/207
37	990830.2btw	2.0
38	990830.1btw, 990923.2btw, 990810.1btw	3.0/757
39	990902.1btw	3.5
40	990831.1btw	2.0/234

Table 1 (cont.). Map numbers, corresponding sites surveyed, and survey effort (person-hours/electroshock seconds) for the Green River Game Land aquatic inventory (see Figure 1).

<u>Map #</u>	<u>Site Number(s)</u>	<u>Survey Effort</u>
41	990831.5btw	1.25/238
42	990831.2btw	1.5/226
43	990831.3btw, 990923.3btw	3.0/504
44	990914.4btw	0.75
45	990914.3btw, 991026.2btw	1.5/184
46	990920.1btw, 991026.1btw	1.75/224
47	990831.4btw	1.5/203
48	990902.2btw, 990923.1btw	2.0/489
49	990908.1btw	1.5
50	990908.2btw	0.25
51	990909.6btw, 991027.5btw	2.5/400
52	990922.3btw	2.25/715
53	990910.1btw	1.25
54	990910.3btw, 991011.6btw	1.5/678
55	990910.2btw, 991011.5btw	2.0/1076
56	990908.3btw, 991011.4btw	1.0/269
57	990908.4btw, 991011.3btw	1.5/270
58	990910.4btw, 991011.2btw	1.5/206
59	990914.1btw	1.75
60	990922.4btw, 991011.1btw	1.75/468
61	990914.2btw	1.5

FRESHWATER MUSSELS AND SPHAERIID CLAMS

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Introduction

The freshwater mussel fauna (Bivalvia: Unionoidea), also referred to as unionids or pearly mussels, is an intriguing, diverse, and important group of mollusks. Unionids are often prominent in macrobenthic aquatic communities where, for the most part, they are sedentary filter-feeders. Because unionids consume a major portion of the suspended particulate matter, they provide a number of important roles in aquatic ecosystems, two of which include serving as biological filters and water quality indicators. Mussels also serve as an important dietary component to a number of animals, and economically, their shells provide the nuclei used in the profitable cultured pearl industry (Theil and Fritz 1993). While not as much information has been ascertained for the sphaeriid clams (Bivalvia: Sphaeriidae), also called pea, pill, nut, or fingernail clams, they too serve an important role in aquatic ecosystems as filter-feeders. As part of the inventory of aquatic animals associated with the state-owned Green River Game Land, we conducted field surveys of freshwater mussels and sphaeriid clams found in waterways occurring in and around the game land to better understand the taxonomy, distribution, and conservation needs of the taxa in North Carolina.

Life History

The life cycle of freshwater mussels is an intricate process that is fairly unique when compared to that of other organisms. Spawning begins with the release of sperm from the excurrent aperture of mature males. As the sperm passively drift with the currents, they enter females through their incurrent aperture. Within sexually mature females, fertilization takes place in the suprabranchial cavity, and the resulting embryos are retained in the marsupial gills until they develop into parasitic larvae called glochidia. Glochidia are obligate parasites and must attach to suitable host fishes. Ortmann (1911) described 2 general reproductive modes for unionids based on the length of time that glochidia are retained in the gills of the female. Bradytictic, or long-term brooders, typically spawn in late summer, brood young over the winter, and release mature glochidia during the following spring or early summer. Tachytictic, or short-term brooders, typically spawn in the spring and release mature glochidia sometime during that summer.

Once maturity is reached, the glochidia are released into the water column through the female's excurrent aperture, from specialized gill pores, or by rupture of the ventral portion of the gill (McMahon 1991). Once released by the female, glochidia passively drift with the currents until they attach to suitable host fishes or die. Mechanisms promoting glochidia-fish contact include respiratory, feeding, and spawning activities of fishes, as well as specialized morphologies and behaviors of particular mussel species (Kraemer 1970, Dartnall and Walkey 1979, Zale and Neves 1982). Attachment occurs on the gills, fins, or scales, depending on the mussel subfamily, and is followed by encystment and metamorphosis into juveniles. Metamorphosis generally occurs over a period of 1-3 weeks (Neves 1991) but can last for a few months (Zale and Neves

1982). Once metamorphosis is complete, the juvenile mussel drops from the host fish and settles into the surrounding substrata where, if conditions are suitable, growth until sexual maturity will occur, and the reproductive cycle is repeated.

Unlike unionids, sphaeriid clams are ovoviviparous, self-fertilizing hermaphrodites. All species brood developing embryos in specialized chambers where maternal nutrients are supplied to the embryos. After maturity is reached, the once developing embryos are released into the water column as miniature adults. Due to their relatively large size as mature embryos, compared with other freshwater bivalves (Mackie 1984), most juvenile sphaeriids disperse between drainage systems by clamping their shells onto things such as aquatic insects (McMahon 1991), feathers of waterfowl (Burky 1983), or the limbs of salamanders (Davis and Gilhen 1982) rather than dispersal by water currents. Given highly variable reproductive success rates, sphaeriids typically have 1-3 reproductive efforts per year (McMahon 1991). *Corbicula fluminea* reproduces in much the same manner as sphaeriid clams but tends to use the water currents as its primary means of dispersal (Williams and McMahon 1986). Most populations of the Asian clam have 2 reproductive efforts per year, one in the spring and the second in the late summer (McMahon 1983a).

Habitat Requirements

Freshwater mussels occur in a variety of habitat types, including both lentic (e.g., lakes, ponds, reservoirs) and lotic (e.g., rivers, streams, creeks) systems. Habitat preferences tend to be species specific, with unionids generally being most successful and prevalent in stable, coarse sand, or sand-gravel mixtures (Way et al. 1990a). Water velocity also plays a critical role in the distribution, diversity, and abundance of mussel populations. Unionids tend to thrive in conditions where water velocities are low enough to allow for substrata stability, but high enough to prevent excessive siltation (Way et al. 1990a). Water velocity also affects the amount of nutrients carried to the filter-feeding organisms. Chemical parameters such as pH and calcium concentrations can influence the distributions of mussel populations as well. The majority of species prefer alkaline water with a pH above 7.0, but unionids can grow and reproduce over a pH range of 5.6 - 8.3 and can tolerate acidic conditions as low as 4.7 (Okland and Kuiper 1982). Typically, habitats of low pH also have low calcium concentrations. Low calcium concentrations can lead to poor growth and shell dissolution in some individuals, especially if the shell is worn (Kat 1982). Given that growth and dissolution rates are affected by many factors other than pH and calcium concentrations, the minimum tolerable values can vary significantly among habitats. Another important factor to mention in the viability of freshwater mussel populations is the need for suitable host fishes. If the proper host fish is not present for a particular mussel species at any given location, then eventually this species will become extirpated from the site regardless of the habitat conditions.

Sphaeriid clams and Asian clams are generally more tolerant than unionids of what we consider to be harsh conditions. Unlike many unionids, the diversity and abundance of some *Pisidium* and *Sphaerium* species are inversely correlated with substrata size (Kilgour and Mackie 1988), which may be associated with sediment organic feeding mechanisms. *C. fluminea* has a much broader substrata range, and has been seen to successfully colonize habitat consisting of bare rock outcrops to habitat with high silt loads. The highest abundances of *C. fluminea* in North Carolina are often associated with sandy disturbed habitats or with lotic habitats below dams

(J.M. Alderman, NC Wildlife Resources Commission, pers. comm.). Sphaeriids have the ability to colonize ponds and lakes where the depth is greater, the flow is negligible, and the sediment and organic loads are high. Again, this may be associated with feeding mechanisms in sphaeriid clams. Chemical parameters such as pH and calcium concentration regulate sphaeriid clams and *C. fluminea* populations in much the same manner that they affect unionid populations.

Taxonomy, Distributions, and Statuses

Freshwater mussels are represented worldwide, with North America containing the largest collection - 297 currently recognized species and subspecies (Williams et al 1993). While unionids are distributed across the entire continent, the greatest diversity lies within the southeastern United States (Neves et al. 1997). North Carolina's share of this diversity is impressive. Once our taxonomic understanding is more complete, approximately 70 species are expected to occur in our state. A significant amount of literature describing site locations for unionids across North America has led to a more refined understanding of the distribution and taxonomy of this fauna.

Of the 297 recognized taxa of freshwater mussels in North America, Williams et al. (1993) recommended that 213 (72%) be considered endangered, threatened, or of special concern. Nearly half of North Carolina's freshwater mussel species are state listed as endangered, threatened, or special concern, and approximately 30% have undetermined statuses (J.M. Alderman, NCWRC, pers. comm.).

Sphaeriid clams are widely distributed and are represented in North America by approximately 38 species (Burch 1975, Turgeon et al. 1998). In North Carolina, there are approximately 13 species (Adams 1990). No species is currently listed at this time.

Anthropogenic effects, such as siltation, riparian habitat destruction, impoundments, pollution, and hydrologic regime alteration are negatively affecting these taxa. With the introduction of exotic species, such as *C. fluminea*, and the impending introduction of *Dreissena polymorpha* (zebra mussel), the situation continues to worsen. Therefore, it is crucial that nongame biologists continue to gather information pertaining to these organisms so proper management plans can be implemented.

Methods

The freshwater mussel and sphaeriid clam survey of Green River Game Land was conducted during the summer and fall of 1999. Refer to the Report Introduction for details on history of land use, drainage basin and waterway descriptions, and a map of all the sites that were surveyed. Waterways were accessed at bridge crossings, from roads running alongside rivers, or by canoe. For smaller streams, we generally sampled upstream for an arbitrary distance (usually about 30 minutes of walking), until we felt that we had covered most habitat types present. For rivers and larger streams, we often snorkeled upstream starting at various points along the river. Typical distances were 100 - 400 meters.

Freshwater mussels were surveyed using a variety of techniques depending on the conditions of the site being surveyed (e.g., water depth, visibility, substrata types). The most prominent

method we used to survey for freshwater mussels was the visual survey. This included snorkeling, the use of a view scope, and the naked eye (where water levels were clear and shallow enough). In areas that were turbid, freshwater mussels were surveyed by tactilely surveying suitable habitat. Freshwater mussels also were surveyed by sieving the substrata through a dip net. If a mussel was located, we typically performed a tactile or visual timed search in the area to determine an approximate abundance at each site. We also noted the type of substrata in which mussel populations colonized to determine if there were any species-specific preferences. Live mussels were identified to species, measured to the nearest mm for length using a Vernier caliper, and returned unharmed to the appropriate habitat. Some individuals were preserved in 70%-denatured ethanol and kept for curation. Shells were collected and identified to species, measured for length (mm), and kept for curation. All common and scientific nomenclature follows Turgeon et al. (1998). Dr. Arthur Bogan of the NC State Museum of Natural Sciences and various NCWRC personnel verified some of the species identifications.

Sphaeriid clams were collected using a variety of methods, including dip netting, and tactile and visual searches. The most prevalent method used was dip netting. This involved running a dip net through vegetation and the substrata to search for the clams. All specimens collected were preserved in 70%-denatured ethanol and identified according to Burch (1975). Specimens also were sent to Dr. Gerald L. Mackie, University of Guelph, Ontario, Canada, for identification confirmation. All common and scientific nomenclature follows Turgeon et al. (1998).

Results

Over 21 days from 10 August to 27 October 1999, 61 sites were inventoried and freshwater mussels were collected or observed at only 14 sites (Figure 2a and Table 2a). Five species were collected during the inventory: *Elliptio complanata* (eastern elliptio), *E. icterina* (variable spike), *E. angustata* (Carolina lance), *Pyganodon cataracta* (eastern floater), and *Utterbackia imbecillis* (paper pondshell). Statistics on valve lengths of each species collected can be seen in Table 2b. Reproduction was observed for the 3 *Elliptio* species.

Elliptio complanata (eastern elliptio) was the most common mussel species found during the Green River Game Land aquatic inventory. A total of 661 live individuals and 31 shells were collected from 13 sites. These sites were limited to both the Green and Broad rivers in Polk and Rutherford counties, respectively, with 1 site including Lake Adger. Individuals were found in a wide array of habitats, ranging from pebble, gravel, and sand substrata with a riffle-run flow regime, to clay and silt in slack water. Time-search abundance estimates of the eastern elliptio ranged from < 1 per hour to nearly 300 mussels per hour, with an average of approximately 75 per hour.

Elliptio icterina (variable spike) and *Elliptio angustata* (Carolina lance) were the next most common species found during the survey. A total of 58 live individuals and 8 shells of the Carolina lance were collected from 5 sites. A total of 14 live individuals and 14 shells of the variable spike were collected from 8 sites. Like the eastern elliptio, both of these species were restricted to the Green and Broad rivers in Polk and Rutherford counties. Individuals of both species were found in a wide array of habitats as well, ranging from pebble, gravel, and sand substrata with a riffle-run flow regime, to clay and silt in slack water. Time-search abundance

estimates of *E. angustata* ranged from < 1 per hour to 11 mussels per hour, with an average of approximately 5 mussels per hour. Likewise, estimates of *E. icterina* ranged from < 1 per hour to only 6 mussels per hour, with an average of < 2 mussels per hour.

Pyganodon cataracta (eastern floater) and *Utterbackia imbecillis* (paper pondshell) were collected from 2 and 1 sites, respectively. Three live eastern floaters were collected from the Green River just upstream of Lake Adger, and 1 shell was collected from an area of the dry lakebed. Three shells of the paper pondshell were collected from this area of the lake as well. Given the low numbers, no abundance estimates were calculated. The live eastern floaters were collected along the bank of the Green River in clay and silt substrata with a slack to stagnant flow regime. The characteristics of the eastern floaters were atypical of other observed individuals. They possessed a more rectangular shape and greater inflation, and the shell was thicker and more stout.

Over the same time period and at the same localities, sphaeriid clams were collected at 24 sites (Figure 2b and Table 2c). Of these 24 sites, *Pisidium casertanum* (ubiquitous peaclam) was found at 6 localities and was the only clam present at these sites. *Corbicula fluminea* was observed at 18 sites and was the only clam present at all of these sites. The Asian clam was found at more sites than the ubiquitous peaclam and the exotic's abundance tended to be greater as well. Over much of its range, the Asian clam was found to be uncommon to common, and abundant at a few sites. On the other hand, the ubiquitous peaclam was rare at all sites from which it was collected. *P. casertanum* specimens were collected from areas with detritus and silt, and the flow regime was typically slack. *Corbicula fluminea* was collected from areas dominated by sand and pebble-gravel, with varying flow types. Reproduction was evident for both species at a majority of the surveyed sites.

Discussion

The overall diversity of the freshwater mussel fauna in Green River Game Land and its associated waterways is low. Further comparisons to other waterways within the Broad River Basin are hampered due to a lack of recent surveys. Correspondence with NCWRC Nongame employees resulted in no additional data. A search of the Nongame database did indicate that *Elliptio complanata*, *Elliptio icterina*, and *Strophitus undulatus* (creeper) had been collected from the Green River during October of 1991. In addition, an unidentified *Elliptio* species was collected from the Broad River. Therefore, our survey appears to be indicative of the area. Since we only surveyed 1 site in the French Broad River Basin, we did not attempt to make any comparisons. Current distribution patterns and ranges of the sphaeriid fauna are much less understood than those for the freshwater mussel fauna. However, the location of a single sphaeriid species, other than the Asian clam, at 6 sites is a clear indicator that the diversity and abundance of these clams also are low for the game land and its associated waterways.

The water body types that we encountered during our survey ranged from piedmont-like to various sized mountain streams. Given the wide range of available habitats, one might have expected the presence of freshwater mussels since they are typically more successful in areas with diverse habitat types (see Background, Habitat Requirements). Additionally, sedimentation did not appear to be having a significant impact (over the surveyed area) resulting in the absence of unionids. Likewise, while the diversity and abundance of some sphaeriid species are inversely

correlated with substrata size (Kilgour and Mackie 1988), it was expected that we would find more than one sporadically distributed, native clam species. Many factors could have contributed to the low diversity, distribution, and abundance of unionids and the negligible presence of sphaeriids, but the most likely factor is the influence of geomorphology and topography. Major landscape scale factors such as these are known to influence and impact the distribution and abundance of organisms over time, and it is possible that the area we surveyed has a naturally low presence of freshwater mussels and pea clams. While water chemistry parameters were not measured at the surveyed sites, cumulative impacts from poor land uses could be affecting the quality of the waterways. The presence of agriculture and logging operations within close proximity to some of the surveyed water bodies has most likely had a negative impact on stream quality through animal waste infiltration and sedimentation, respectively. Effects from urbanization around towns such as Hendersonville also are likely impacting the Green River and Broad River subbasins. Additional efforts may lead to more positive results, but it is likely that the results reported herein are indicative of this area.

While no threatened or endangered bivalve species was collected during the survey of Green River Game Land, continual research and status surveys are needed to determine the present status of each species. Current land management practices, including agriculture and urbanization, are having an effect on the bivalve fauna in North Carolina. As nongame biologists, we need to identify which species are at risk and identify ways to reduce or eliminate the impacts.

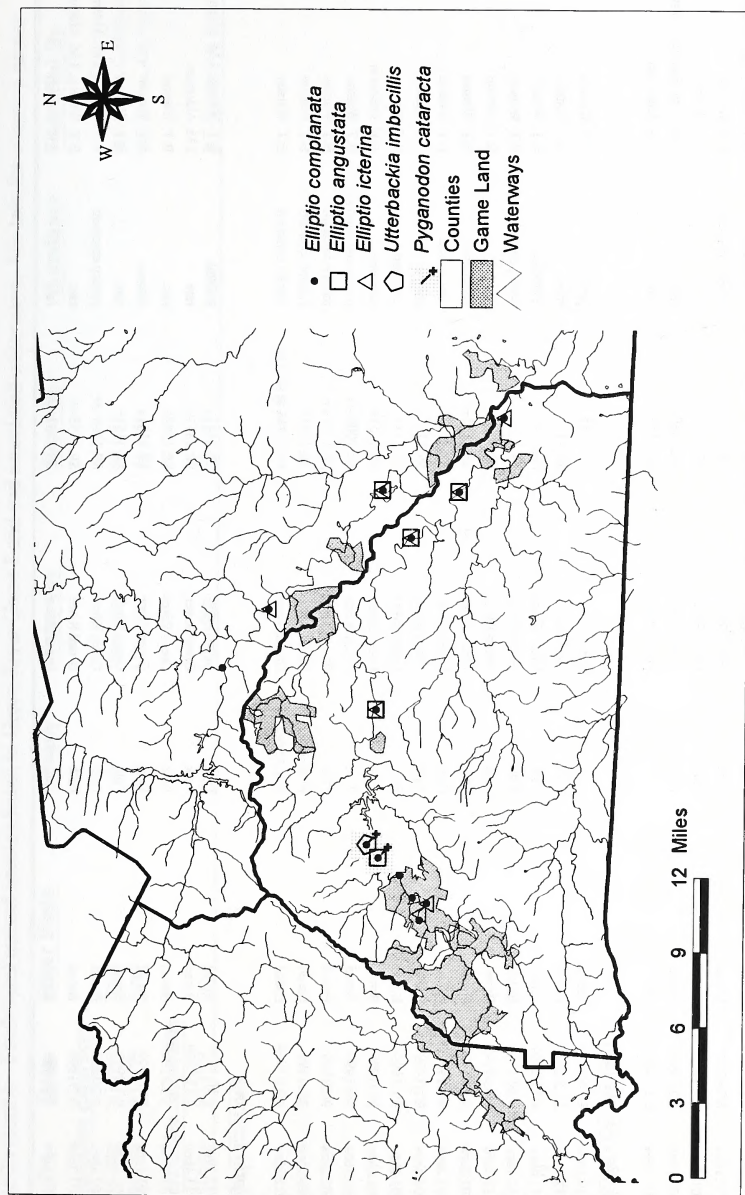


Figure 2a. Map of sites indicating where each species of freshwater mussel was collected in the Green River Game Land aquatic inventory, Henderson, Polk, and Rutherford counties, North Carolina, 1999.

Table 2a. Freshwater mussel species found in Green River Game Land and associated waterways. See text for common names.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Elliptio angustata</i>							
990810.1btw	8/10/1999	Broad	Polk	Green River	SR 1331	present	J.M. Alderman
990813.4btw	8/13/1999	Broad	Polk	Green River	SR 1313+	uncommon	B.T. Watson, J.M. Alderman
990830.1btw	8/30/1999	Broad	Polk	Green River	SR 1331+	patchy uncommon	B.T. Watson
990901.5btw	9/1/1999	Broad	Polk	Green River	SR 1155	rare	B.T. Watson
990902.1btw	9/2/1999	Broad	Polk	Green River	SR 1005 -/+	rare	J.M. Alderman, B.T. Watson
990902.2btw	9/2/1999	Broad	Polk	Broad River	SR 1155-/+	rare	J.M. Alderman
<i>Elliptio complanata</i>							
990810.1btw	8/10/1999	Broad	Polk	Green River	SR 1331	present	B.T. Watson
990812.1btw	8/12/1999	Broad	Polk	Green River	SR 1151-	rare	B.T. Watson
990813.4btw	8/13/1999	Broad	Polk	Green River	SR 1313+	abundant	B.T. Watson
990830.1btw	8/30/1999	Broad	Polk	Green River	SR 1331+	patchy abundant	B.T. Watson
990831.3btw	8/31/1999	Broad	Polk	Green River	SR 1302+	rare	B.T. Watson
990901.2btw	9/1/1999	Broad	Polk	Green River	SR 1151+	uncommon	B.T. Watson
990901.3btw	9/1/1999	Broad	Polk	Green River	SR 1151+	uncommon	B.T. Watson
990901.4btw	9/1/1999	Broad	Polk	Green River	SR 1151+	abundant	B.T. Watson
990901.5btw	9/1/1999	Broad	Polk	Green River	SR 1155+	common	B.T. Watson
990901.6btw	9/1/1999	Broad	Polk	Lake Adger	SR 1151+	common	A.H. Fullerton
990902.1btw	9/2/1999	Broad	Polk	Green River	SR 1005 -/+	patchy uncommon	B.T. Watson
990902.2btw	9/2/1999	Broad	Polk	Broad River	SR 1155-/+	patchy common	B.T. Watson
990909.6btw	9/9/1999	Broad	Rutherford	Broad River	SR 1181+	patchy common	B.T. Watson
990922.3btw	9/22/1999	Broad	Rutherford	Broad River	US 64-74A @ SR1184-	patchy common	B.T. Watson
<i>Elliptio icterina</i>							
990810.1btw	8/10/1999	Broad	Polk	Green River	SR 1331	present	B.T. Watson, J.M. Alderman
990813.4btw	8/13/1999	Broad	Polk	Green River	SR 1313+	rare	J.M. Alderman
990831.3btw	8/31/1999	Broad	Polk	Green River	SR 1302+	rare	B.T. Watson
990901.1btw	9/1/1999	Broad	Polk	Green River	SR 1151+	rare	B.T. Watson
990901.2btw	9/1/1999	Broad	Polk	Green River	SR 1151+	rare	B.T. Watson
990902.1btw	9/2/1999	Broad	Polk	Green River	SR 1005 -/+	patchy common	B.T. Watson, J.M. Alderman
990902.2btw	9/2/1999	Broad	Polk	Broad River	SR 1155-/+	rare	B.T. Watson, J.M. Alderman
990909.6btw	9/9/1999	Broad	Rutherford	Broad River	SR 1181+	rare	B.T. Watson

Table 2a (cont.). Freshwater mussel species found in Green River Game Land and associated waterways. See text for common names.

<u>Site No.</u>	<u>Date</u>	<u>River Basin</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<i><u>Pyganodon cataracta</u></i>							
990901.5btw	9/1/1999	Broad	Polk	Green River	SR 1155	rare	B.T. Watson, C. McGrath
990901.6btw	9/1/1999	Broad	Polk	Lake Adger	SR 1151+	present	B.T. Watson, A.H. Fullerton
<i><u>Unterbackia imbecillis</u></i>							
990901.6btw	9/1/1999	Broad	Polk	Lake Adger	SR 1151+	present	B.T. Watson, A.H. Fullerton

Table 2b. Statistics on valve lengths of live freshwater mussels and shells found in the Green River Game Land and associated waterways. See text for common names.

<i>Elliptio angustata</i>		Avg	Std	Min	Max
live (58 records)		66.4	9.0	29.0	85.0
shell (8 records)		66.5	4.4	61.0	73.0
Species Total (66 records)		66.4	8.6	29.0	85.0
<i>Elliptio complanata</i>					
live (661 records)		108.0	13.2	17.0	149.0
shell (31 records)		98.3	23.4	38.0	132.0
Species Total (692 records)		107.5	13.9	17.0	149.0
<i>Elliptio icterina</i>					
live (14 records)		50.5	21.4	17.0	78.0
shell (14 records)		41.7	16.3	27.0	80.0
Species Total (28 records)		46.1	19.2	17.0	80.0
<i>Pyganodon cataracta</i>					
live (3 records)		93.3	3.2	91.0	97.0
shell (1 record)		53.0		53.0	53.0
Species Total (4 records)		83.3	20.3	53.0	97.0
<i>Uterbackia imbecillis</i>					
shell (3 records)		61.7	9.3	54.0	72.0
Species Total (3 records)		61.7	9.3	54.0	72.0

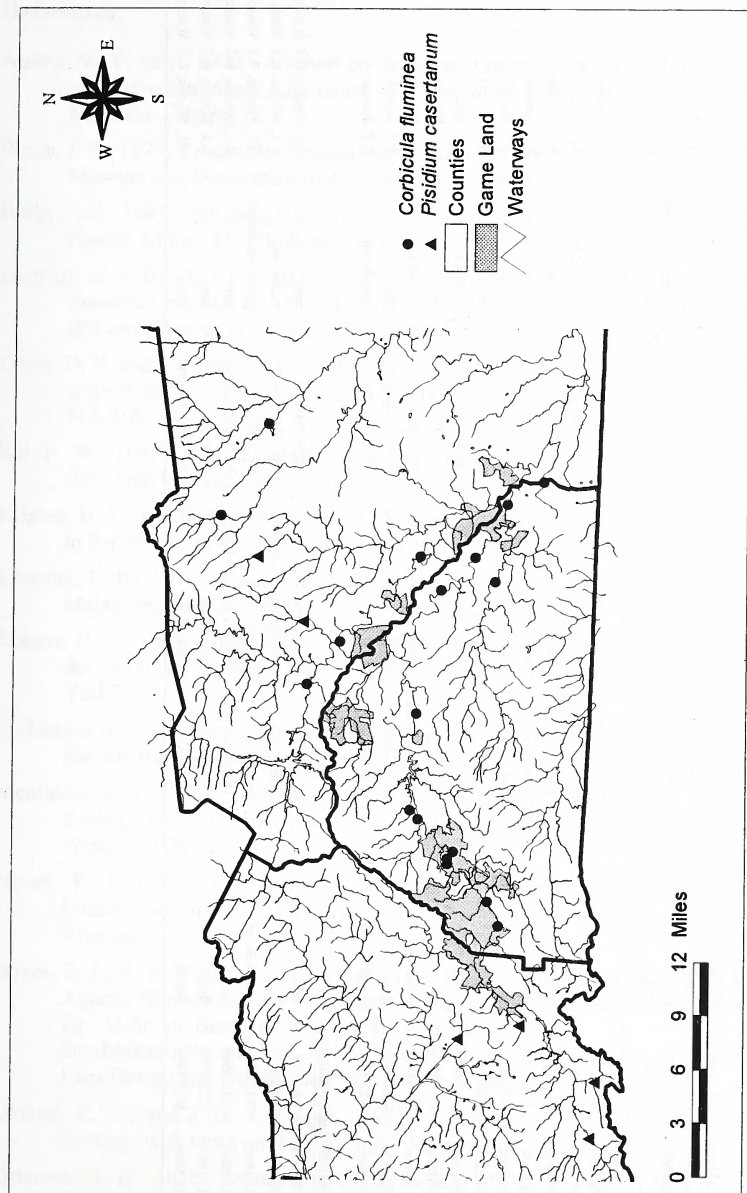


Figure 2b. Map of sites indicating where each species of sphaeriid clam was collected in the Green River Game Land aquatic inventory, Henderson, Polk, and Rutherford counties, North Carolina, 1999.

Table 2c. Sphaeriid clam species found in Green River Game Land and associated waterways. See text for common names.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Corbicula fluminea</i>							
990811.1btw	8/1/1999	Broad	Polk	Green River	SR 1151-	uncommon	B.T. Watson
990811.2btw	8/1/1999	Broad	Polk	Green River	SR 1151-/+	patchy uncommon	B.T. Watson
990812.1btw	8/12/1999	Broad	Polk	Green River	SR 1151-	uncommon	B.T. Watson
990813.4btw	8/13/1999	Broad	Polk	Green River	SR 1313+	abundant	B.T. Watson
990830.1btw	8/30/1999	Broad	Polk	Green River	SR 1331+	patchy uncommon	B.T. Watson
990831.1btw	8/31/1999	Broad	Polk	White Oak Creek	SR 1005-	uncommon	B.T. Watson
990831.3btw	8/31/1999	Broad	Polk	Green River	SR 1302+	uncommon	B.T. Watson
990901.1btw	9/1/1999	Broad	Polk	Green River	SR 1151+	uncommon	B.T. Watson
990901.2btw	9/1/1999	Broad	Polk	Green River	SR 1151+	uncommon	B.T. Watson
990901.5btw	9/1/1999	Broad	Polk	Green River	SR 1155	uncommon	B.T. Watson
990901.6btw	9/1/1999	Broad	Polk	Lake Adger	SR 1151+	common	B.T. Watson
990902.1btw	9/2/1999	Broad	Polk	Green River	SR 1005 -/+	patchy common	B.T. Watson
990902.2btw	9/2/1999	Broad	Polk	Broad River	SR 1155-/+	patchy common	B.T. Watson
990909.6btw	9/9/1999	Broad	Rutherford	Broad River	SR 1181+	common	B.T. Watson
990914.1btw	9/14/1999	Broad	Rutherford	Cathey's Creek	SR 1325+	rare	B.T. Watson
990914.4btw	9/14/1999	Broad	Rutherford/Polk	Henson Creek	SR 1300-	common	B.T. Watson
990922.3btw	9/22/1999	Broad	Rutherford	Broad River	US 64-74A @ SR 1184-	abundant	B.T. Watson
990922.4btw	9/22/1999	Broad	Rutherford	Second Broad River	SR 1602-	uncommon	B.T. Watson
<i>Pisidium casertanum</i>							
990908.3btw	9/8/1999	Broad	Rutherford	Knob Creek	US 64-74A+	rare	G.L. Mackie, B.T. Watson
990910.4btw	9/10/1999	Broad	Rutherford	East Branch (Mountain Ck)	SR 1331-	patchy rare	G.L. Mackie, B.T. Watson
990915.1btw	9/15/1999	French Broad	Henderson	Bat Fork Creek	SR 1783-/+	patchy uncommon	G.L. Mackie, B.T. Watson
990915.4btw	9/15/1999	Broad	Henderson	Tributary to Green River	US 176 (beside)+	rare	G.L. Mackie, B.T. Watson
990921.1btw	9/21/1999	Broad	Henderson	Green River	SR 1104+	rare	G.L. Mackie, B.T. Watson
990921.3btw	9/21/1999	Broad	Henderson	Bob's Creek	SR 1101 @ SR 1104-	rare	G.L. Mackie, B.T. Watson

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AQUATIC SNAILS

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Introduction

Freshwater snails (Mollusca: Gastropoda) are among the most ubiquitous organisms of shallow littoral zones in lakes and streams. Due to their behavior, widespread distribution, and commonly high abundance, snails serve a number of important roles in aquatic ecosystems. These include driving predator-prey interactions (Vermeij and Covich 1978, Lodge et al. 1987), serving as a dietary component to fish and wildlife, acting as water quality indicators, and most importantly, grazing on nuisance algae and detritus. However, freshwater snails are often overlooked in part due to their small size, perceived lack of charisma, cryptic habits, and the lack of readily available comprehensive guides for identification. As part of the inventory of aquatic animals associated with the state-owned Green River Game Land, we conducted field surveys of aquatic snails found in waterways occurring in and around the game land to better understand the taxonomy, distribution, and conservation needs of the taxa in North Carolina.

Life History

Much information about the reproductive cycles of freshwater snails has been ascertained due to the ease of laboratory rearing. From this information, 2 typical categories have been developed in which snails can be placed reproductively (Russell-Hunter 1978, Calow 1978). The first category includes annual adults that reproduce in the spring and die (semelparous). Most pulmonates (lung breathing), which are oviparous hermaphrodites, belong to this group including the genera *Lymnaea* and *Physa*. The second category includes perennial adults that reproduce in both spring and late summer. Most prosobranchs (gill breathing), which are dioecious and can be oviparous or ovoviviparous, belong to this group. These species are iteroparous and often live and reproduce for 4-5 years. Prosobranchs also are often sexually dimorphic, with females living longer than males (Brown et al. 1989).

Habitat and Food Requirements

Freshwater snails occupy a variety of habitat types, including both lentic (e.g., lakes, ponds, reservoirs) and lotic (e.g., rivers, streams, creeks) systems. Habitat preferences tend to be species specific, with well-documented substratum selection (Brown 1991). In general, silty habitats with slow-moving currents are colonized predominately by pulmonates or detritivorous prosobranchs, whereas limpets or prosobranch grazers colonize fast-current localities (Harman 1972). Many biotic and abiotic factors regulate the distribution of freshwater snails, with water hardness and pH considered to be the major determinants (Macan 1950, Pip 1986). However, it has been suggested that physiochemical factors such as calcium concentrations may only act to limit successful invasion of habitats with extreme levels of these factors (Lodge et al. 1987). Other factors such as dispersal ability and adequate substrata may play a more prominent role in snail distribution.

Freshwater snails are predominantly herbivores or detritivores, although they can ingest carrion (Bovbjerg 1968) or passively consume small invertebrates associated with periphyton (Cuker 1983a). Apparently, they prefer periphyton because it is easier to scrape than macrophytes, and it contains higher concentrations of nitrogen and other limiting nutrients (Russell-Hunter 1978, Aldridge 1983). Algae and diatoms also are prominent sources of nutrients for freshwater snails (Lodge 1986). While macrophytes are not the preferred source of nutrients for most freshwater snails, significant consumption can occur if snail densities reach high levels (Sheldon 1987).

Taxonomy, Distribution, and Statuses

Freshwater snails are divided into 2 groups – prosobranchs and pulmonates. Prosobranch snails are gill breathing and have a calcareous plate called an operculum that seals the aperture when the snail withdraws into its shell. Pulmonate snails are lung breathing and lack an operculum. Of the approximately 500 species recognized in North America, there are 49 genera and 349 species of prosobranch snails and 29 genera and 150 species of pulmonate snails (Burch 1982). While snails are widespread across the continent, they have reached their greatest abundance and diversity within the streams of the southeastern United States (Brown 1991). In North Carolina, there are approximately 52 species representing 10 families (Bogan 1997). Since very little work has been done to monitor freshwater snail populations, the current status of many species within North Carolina is undetermined. It is unknown as to magnitude of impact that anthropogenic effects such as siltation, riparian habitat destruction, impoundments, pollution, and hydrologic regime alteration have had on the state's snail fauna. Therefore, it is crucial that nongame biologists continue to gather information pertaining to these organisms so proper management plans can be implemented.

Methods

The snail survey of Green River Game Land was conducted during the summer and fall of 1999. Refer to the Report Introduction for details on history of land use, drainage basin and waterway descriptions, and a map of all the sites that were surveyed. Waterways were accessed at bridge crossings, from roads running alongside rivers, or by canoe. For smaller streams, we generally sampled upstream for an arbitrary distance (usually about 30 minutes of walking), until we felt that we had covered most habitat types present. For rivers and larger streams, we often snorkeled upstream starting at various points along the river. Typical distances were 100 - 400 meters.

Freshwater snails were collected using a variety of techniques depending on the conditions of the site being surveyed (e.g., water depth, visibility, substrata types). The most common methods used to sample the snail fauna were visual searches and dip netting. The visual search basically involved examining rocky substrata, woody debris, vegetation, cans and bottles, and other items that snails might colonize. Dip netting involved running a 1/8-inch mesh dip net through vegetation and the substrata to collect snails. Other techniques used to collect snails included snorkeling, tactile searches, and the use of a viewscope. Habitat preference, relative abundance, and recent reproduction for snail species were noted at each site. Snails were preserved in 70%-denatured alcohol and identified according to Burch (1989) and Basch (1963). Scientific names are according to Turgeon et al. (1998). Dr. Arthur E. Bogan, curator of aquatic invertebrates at

the NC State Museum of Natural Sciences, verified some of the species identifications. Not all snails collected were preserved for obvious conservation and ethical reasons.

Results

Over 21 days from 10 August to 27 October 1999, 60 sites were inventoried (site 25 was searched for mussels only) and aquatic snails were collected or observed at 59 localities (Figures 3a-b). Nine species representing 6 families were documented during the Green River Game Land survey (Tables 3a and 3b). The relative abundance of each species varied, but by far the most abundant and widespread species was *Elimia symmetrica*, with the snail residing at 46 sites (Figure 3a). *Ferrissia* sp. was the next most abundant gastropod, residing at 38 sites (Figure 3b). Due to species level variation and the uncertainty of positively discerning *Ferrissia* specimens, all specimens of this genus were identified as *Ferrissia* sp. Both of the aforementioned species ranged in abundance from rare to abundant, but overall they were common in the survey area with *E. symmetrica* being the more abundant of the 2 species. The remaining snail species were represented over a much smaller number of sites, ranging from 1-12, where they were mostly common to abundant except for *Physella* sp. and *Micromenetus dilatatus*, which were rare to uncommon over their ranges. Recent reproduction was seen at a number of sites for all the snail species collected during the survey, but it was definitely more pronounced amongst the *Elimia* species and *Ferrissia* sp. Due to the minute size of some of the species (e.g., *Micromenetus dilatatus* and *Somatogyrus* sp.), it was difficult to confirm whether these were adults or juveniles and typically reproduction was not recorded.

Elimia symmetrica (symmetrical elimia) was typically found on pebble, gravel, and cobble in piedmont and mountain-like streams. On occasion, it also was found on woody debris, vegetation, and in sand. The symmetrical elimia was typically associated with moderate to fast flow, which limited its range to riffle-run stream reaches. However, it also could be found in slack water areas on occasion. This species was found in Henderson, Polk, and Rutherford counties within the Broad River Basin, but not at the single site we sampled in the French Broad River Basin.

Elimia catenaria (gravel elimia) was very similar to *E. symmetrica* in the type of substrata and flow regime it occupied, with the 2 species often overlapping. However, of the 12 sites from which the gravel elimia was collected, 11 were confined to the Green River within Polk County. The twelfth site was a tributary to the Green River where the species was noted as rare (4 specimens collected). Given its limited range within the Green River, perhaps this species is more successful in larger streams and rivers that are dominated by pebble, gravel, and cobble substrata, and a riffle-run flow regime.

Ferrissia sp. was found over a wide array of substrata types, ranging from pebble, gravel, and cobble, to debris (woody and man-made) and detritus. Similarly, it was found in a variety of flow regimes, ranging from riffle-run to pool. This ancyliid was found in both river basins and in each county surveyed.

Physella sp. (physa snail) and *Pseudosuccinea columella* (mimic lymnaea) were found in detritus, on vegetation and debris (woody and man-made), and on pebble and gravel. The flow regime typically was slack to stagnant where these specimens were found, which is common for

these species. *Physella* sp. and *P. columella* were collected from 12 and 3 sites, respectively, from both the Broad and French Broad river basins. The physa snail was collected from all 3 counties surveyed, while the mimic lymnaea was not collected in Polk County.

Helisoma anceps (two-ridged rams-horn) was typically found in slack-water conditions, but in different types of substrata. In the Green River, the species was associated with pebble, gravel, and silt, whereas, at the other 3 sites it was collected from the species was typically associated with silt and detritus and occasionally rocky substrata. Overall, the two-ridged rams-horn's distribution is widespread and disjunct, with specimens being collected from 2 sites in Rutherford County, 1 site in Polk County, and 1 site in Henderson County.

Micromenetus dilatatus (bugle sprite) and *Somatogyrus* sp. (pebblesnail) were individually collected from a single site in Rutherford and Polk counties, respectively. The bugle sprite was found amongst detritus and woody debris in slower moving water, while the pebblesnail was found on pebble and gravel in riffle-run type flow conditions.

Over the surveyed area, *Leptoxis carinata* (crested mudalia) was isolated to 1 site in the Green River (Broad River Basin, Polk County). This site was characterized by pebble, gravel, cobble, and bedrock substrata with a riffle-run flow regime. Specimens from this site were originally identified and collected with *Elimia symmetrica*, so it is possible that the species is more widespread than our survey indicates.

Discussion

Overall, the diversity and abundance of freshwater snails in the waterways associated with Green River Game Land appear to be moderate. Extension of the survey to incorporate other tracts of the game land than the nearly 12,000 acre state-owned tract along the Henderson-Polk county line, definitely increased the number of species collected during this survey. Only 4 of the 9 species collected during the inventory were actually collected from this main portion of the game land or in the immediate Broad River Basin vicinity. Continued input into how some of these smaller, privately owned pieces of the game land are managed is important to all the species. Since many of these tracts are within or lie along the Green River or Broad River subbasins, certain land management practices may have a detrimental impact on the existence of these additional snail species, as well as the distribution and health of all the snail species.

Further comparisons to other waterways within the Broad River Basin are hampered due to a lack of recent surveys. Correspondence with NCWRC Nongame employees resulted in no additional data, and a search of the Nongame database indicated no records for snails in this river basin. Since we only surveyed 1 site in the French Broad River Basin, we did not attempt to make any comparisons. The influence of geomorphologic and topographic factors has most likely structured the current gastropod fauna of the area. Major landscape scale factors such as these are known to influence and impact the distribution and abundance of organisms over time. While water chemistry parameters were not measured at the surveyed sites, cumulative impacts from poor land uses could be affecting the quality of the waterways. The presence of agriculture and logging operations within close proximity to some of the surveyed water bodies has most likely had a negative impact on stream quality through animal waste infiltration and sedimentation, respectively. Effects from urbanization around towns such as Hendersonville

also are likely impacting the Green River and Broad River subbasins. While these impacts may not have had a significant effect on the current aquatic snail diversity, they are likely affecting the current abundance and distribution of each species.

Taxonomic uncertainties within the freshwater snail fauna make the results here subject to revision. For example, the differentiation between *F. rivularis* and *F. fragilis* is difficult due to shell shape variation. Therefore, a common factor used to distinguish these species is the habitat they are collected in, with *F. rivularis* colonizing rivers and streams and *F. fragilis* inhabiting stagnant areas such as ditches, ponds, and backwater areas. All of the limpets identified in this survey were assigned to *Ferrissia* sp., but it is likely that at least both species inhabit some of the sites that were surveyed, with *F. rivularis* more dominant in the region. Likewise, there is uncertainty with the taxonomic assignments within the *Elimia* genera (Burch 1989). At this time, it is not definitely known if *Elimia proxima* and *E. symmetrica* are 2 distinct species, or a single, highly variable species. Typically, the specimens we collected have been identified as *E. proxima* but it is thought that this species may be limited to the Tennessee River Basin (A.E. Bogan, NCSM, pers. comm.) within North Carolina. At this time, we have chosen to use *Elimia symmetrica* to classify these specimens. Likewise, many uncertainties exist as to the taxonomy of *Physella* and hydrobiids without examination of soft parts (Burch 1989). Since we did not preserve the specimens for the examination of soft parts, we identified these specimens to genus only.

No rare or significant snail species was found during the Green River Game Land aquatic inventory. However, much more research and status surveys are needed to determine which species are significant or rare on a statewide basis. Current land management practices, including agriculture and urbanization, are having an effect on the snail fauna in North Carolina. As nongame biologists, we need to identify which species are at risk and identify ways to reduce or eliminate impacts.

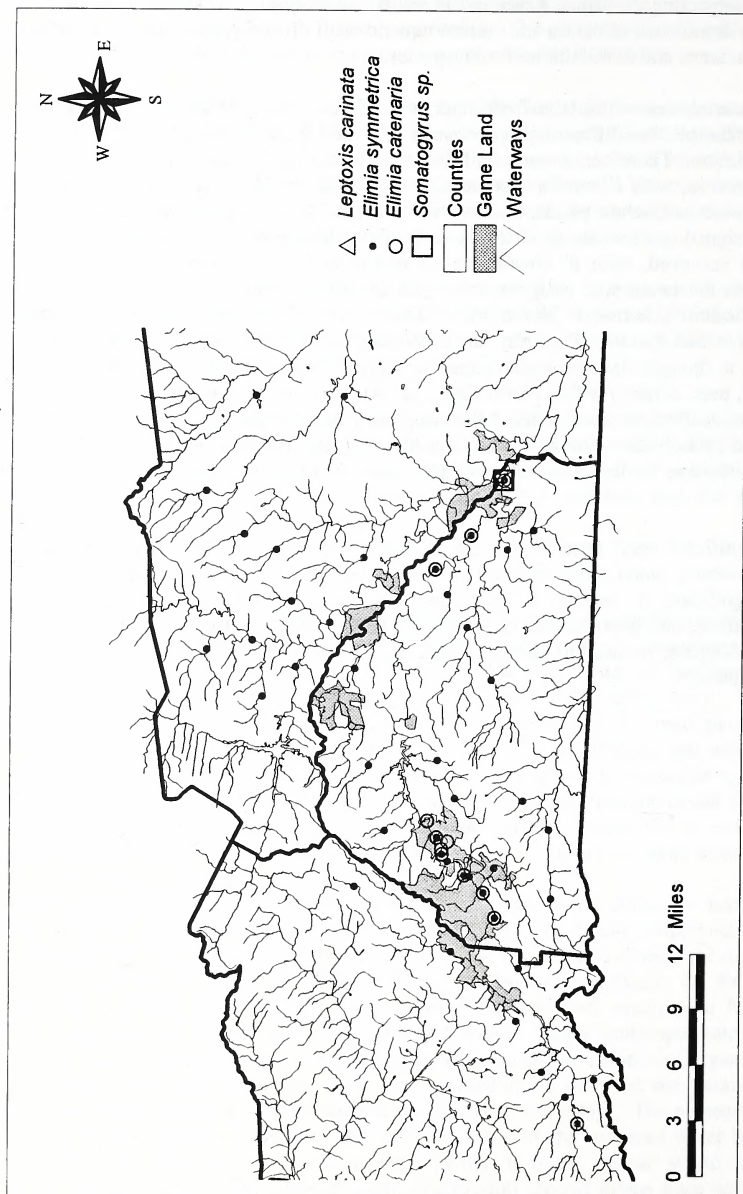


Figure 3a. Map of sites indicating where each species of prosobranch snail was collected in the Green River Game Land aquatic inventory, Henderson, Polk, and Rutherford counties, North Carolina, 1999.

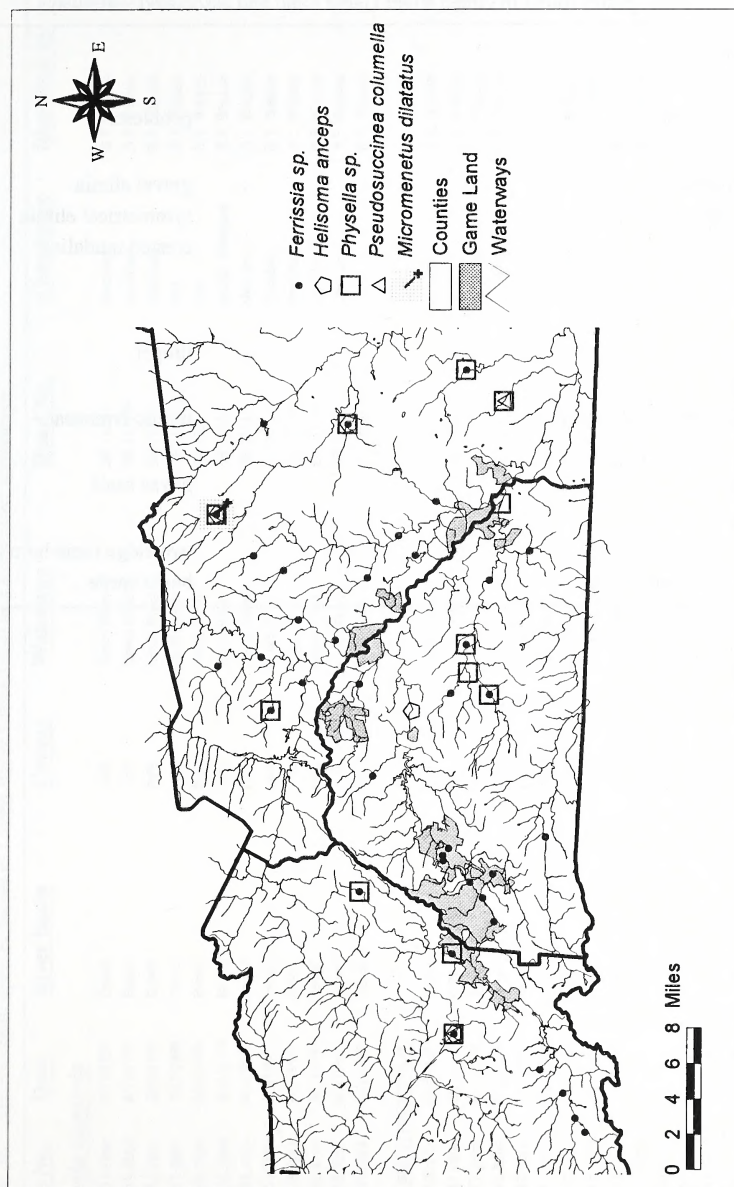


Figure 3b. Map of sites indicating where each species of pulmonate snail was collected in the Green River Game Land aquatic inventory, Henderson, Polk, and Rutherford counties, North Carolina, 1999.

Table 3a. Aquatic snail species found in Green River Game Land and associated waterways.

Prosobranchia

Hydrobiidae

Somatogyrus sp. pebblesnail

Pleuroceridae

Elimia catenaria gravel elimia

Elimia symmetrica symmetrical elimia

Leptoxis carinata crested mudalia

Pulmonata

Ancylidae

Ferrissia sp. limpet

Lymnaeidae

Pseudosuccinea columella mimic lymnaea

Physidae

Physella sp. physa snail

Planorbidae

Helisoma anceps two-ridge rams-horn

Micromenetus dilatatus bugle sprite

Table 3b. Aquatic snail species found in Green River Game Land and associated waterways.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Elimia catenaria</i>							
990811.1btw	8/11/1999	Broad	Polk	Green River	SR 1151-	abundant	B.T. Watson
990811.2btw	8/11/1999	Broad	Polk	Green River	SR 1151-/+	abundant	B.T. Watson
990812.1btw	8/12/1999	Broad	Polk	Green River	SR 1151-	abundant	B.T. Watson
990812.3btw	8/12/1999	Broad	Polk	Gadd Creek	SR 1151-	rare	B.T. Watson
990830.1btw	8/30/1999	Broad	Polk	Green River	SR 1331+	rare	B.T. Watson
990831.3btw	8/31/1999	Broad	Polk	Green River	SR 1302+	patchy abundant	B.T. Watson
990901.1btw	9/1/1999	Broad	Polk	Green River	SR 1151+	abundant	B.T. Watson
990901.2btw	9/1/1999	Broad	Polk	Green River	SR 1151+	abundant	B.T. Watson
990901.3btw	9/1/1999	Broad	Polk	Green River	SR 1151+	abundant	B.T. Watson
990901.4btw	9/1/1999	Broad	Polk	Green River	SR 1151+	abundant	B.T. Watson
990902.1btw	9/2/1999	Broad	Polk	Green River	SR 1005 -/+	abundant	B.T. Watson
990921.2btw	9/21/1999	Broad	Henderson	Rock Creek	SR 1106-	rare	B.T. Watson
<i>Elimia symmetrica</i>							
990810.2btw	8/10/1999	Broad	Polk	Cove Creek	SR 1142	present	B.T. Watson
990811.1btw	8/11/1999	Broad	Polk	Green River	SR 1151-	abundant	B.T. Watson
990811.2btw	8/11/1999	Broad	Polk	Green River	SR 1151-/+	patchy uncommon	B.T. Watson
990811.3btw	8/11/1999	Broad	Polk	Cove Creek	SR 1151-/+	patchy uncommon	B.T. Watson
990812.1btw	8/12/1999	Broad	Polk	Green River	SR 1151-	rare	B.T. Watson
990812.2btw	8/12/1999	Broad	Polk	Laurel Branch	SR 1151-	abundant	B.T. Watson
990812.3btw	8/12/1999	Broad	Polk	Gadd Creek	SR 1151-	abundant	B.T. Watson
990813.1btw	8/13/1999	Broad	Polk	Cove Creek	SR 1142+	common	B.T. Watson
990813.2btw	8/13/1999	Broad	Polk	Ostin Creek	SR 1142-/+	common	B.T. Watson
990813.3btw	8/13/1999	Broad	Polk	Silver Creek	SR 1138-/+	uncommon	B.T. Watson
990830.1btw	8/30/1999	Broad	Polk	Green River	SR 1331+	patchy uncommon	B.T. Watson
990830.2btw	8/30/1999	Broad	Polk	Wheat Creek	SR 1329+	uncommon	B.T. Watson
990831.2btw	8/31/1999	Broad	Polk	Green River	SR 1340+	patchy common	B.T. Watson
990831.3btw	8/31/1999	Broad	Polk	Green River	SR 1302+	rare	B.T. Watson
990831.5btw	8/31/1999	Broad	Polk	Mill Creek	SR 1339-	uncommon	B.T. Watson
990901.3btw	9/1/1999	Broad	Polk	Green River	SR 1151+	abundant	B.T. Watson
990902.1btw	9/2/1999	Broad	Polk	Green River	SR 1005 -/+	rare	B.T. Watson
990908.2btw	9/8/1999	Broad	Rutherford	Maple Creek	by SR 1178 -/+	rare	B.T. Watson

Table 3b (cont.). Aquatic snail species found in Green River Game Land and associated waterways.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Elimia symmetrica</i>							
990908.3btw	9/8/1999	Broad	Rutherford	Knob Creek	US 64-74A+	patchy common	B.T. Watson
990908.4btw	9/8/1999	Broad	Rutherford	West Branch (Mountain Ck)	SR 1351+	patchy uncommon	B.T. Watson
990909.1btw	9/9/1999	Broad	Polk	White Oak Creek	SR 1526-	rare	B.T. Watson
990909.4btw	9/9/1999	Broad	Polk	Machine Creek	SR 1330-	abundant	B.T. Watson
990909.5btw	9/9/1999	Broad	Polk	Walnut Creek	SR 1311-	patchy uncommon	B.T. Watson, A.E. Bogan
990909.6btw	9/9/1999	Broad	Rutherford	Broad River	SR 1181+	patchy uncommon	B.T. Watson
990910.1btw	9/10/1999	Broad	Rutherford	Bills Creek	SR 1008-/+	abundant	B.T. Watson
990910.2btw	9/10/1999	Broad	Rutherford	Cove Creek	SR 1337-	abundant	B.T. Watson
990910.3btw	9/10/1999	Broad	Rutherford	Cedar Creek	SR 1008+	rare	B.T. Watson
990910.4btw	9/10/1999	Broad	Rutherford	East Branch (Mountain Ck)	SR 1331-	uncommon	B.T. Watson
990914.1btw	9/14/1999	Broad	Rutherford	Cathey's Creek	SR 1325+	uncommon	B.T. Watson
990914.2btw	9/14/1999	Broad	Rutherford	Holland Creek	SR 1538-	common	B.T. Watson
990914.4btw	9/14/1999	Broad	Rutherford/Polk	Henson Creek	SR 1300-	abundant	B.T. Watson
990915.2btw	9/15/1999	Broad	Henderson	Joe Creek	SR 1106+	abundant	B.T. Watson
990915.3btw	9/15/1999	Broad	Henderson	Freeman Creek	by SR 1115-/+	uncommon	B.T. Watson
990915.4btw	9/15/1999	Broad	Henderson	Tributary to Green River	US 176 (beside)+	patchy common	B.T. Watson
990915.5btw	9/15/1999	Broad	Henderson	Camp Creek	SR 1836-/+	common	B.T. Watson
990921.1btw	9/21/1999	Broad	Henderson	Green River	SR 1104+	common	B.T. Watson
990921.2btw	9/21/1999	Broad	Henderson	Rock Creek	SR 1106-	abundant	B.T. Watson, A.E. Bogan
990921.3btw	9/21/1999	Broad	Henderson	Bob's Creek	SR 1101 @ SR 1104-	patchy common	B.T. Watson
990921.4btw	9/21/1999	Broad	Polk	North Pacolet River	US 176-	patchy uncommon	B.T. Watson
990921.5btw	9/21/1999	Broad	Polk	North Pacolet River	US 176 @ SR 1125-/+	rare	B.T. Watson
990921.6btw	9/21/1999	Broad	Polk	Skyuka Creek	SR 1135-	uncommon	B.T. Watson
990922.1btw	9/22/1999	Broad	Polk	Britten Creek	SR 1158-/+	uncommon	B.T. Watson
990922.2btw	9/22/1999	Broad	Polk	Unnamed tributary to Lake Adger	SR 1156-/+	patchy uncommon	B.T. Watson
990922.3btw	9/22/1999	Broad	Rutherford	Broad River	US 64-74A @ SR 1184-	rare	B.T. Watson
990922.4btw	9/22/1999	Broad	Rutherford	Second Broad River	SR 1602-	common	B.T. Watson
990922.5btw	9/22/1999	Broad	Henderson	Little Hungry River	SR 1713+	rare	B.T. Watson
990922.6btw	9/22/1999	Broad	Henderson	Big Hungry River	SR 1802-/+	rare	B.T. Watson

Table 3b (cont.). Aquatic snail species found in Green River Game Land and associated waterways.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Ferissia</i> sp.							
990811.1btw	8/11/1999	Broad	Polk	Green River	SR 1151-	uncommon	B.T. Watson
990811.2btw	8/11/1999	Broad	Polk	Green River	SR 1151-/+	uncommon	B.T. Watson
990811.3btw	8/11/1999	Broad	Polk	Cove Creek	SR 1151-/+	common	B.T. Watson
990812.1btw	8/12/1999	Broad	Polk	Green River	SR 1151-	patchy common	B.T. Watson
990813.1btw	8/13/1999	Broad	Polk	Cove Creek	SR 1142+	patchy rare	B.T. Watson
990831.1btw	8/31/1999	Broad	Polk	White Oak Creek	SR 1005-	patchy uncommon	B.T. Watson
990831.2btw	8/31/1999	Broad	Polk	Green Creek	SR 1340+	rare	B.T. Watson
990831.4btw	8/31/1999	Broad	Rutherford	Cleghom Creek	SR 1149-	patchy uncommon	B.T. Watson
990901.1btw	9/1/1999	Broad	Polk	Green River	SR 1151+	patchy uncommon	B.T. Watson
990901.2btw	9/1/1999	Broad	Polk	Green River	SR 1151+	uncommon	B.T. Watson
990902.2btw	9/2/1999	Broad	Polk	Broad River	SR 1155-/+	patchy uncommon	B.T. Watson
990908.1btw	9/8/1999	Broad	Rutherford	Mountain Creek	NC 108-/+	patchy uncommon	B.T. Watson
990908.2btw	9/8/1999	Broad	Rutherford	Maple Creek	by SR 1178 -/+	rare	B.T. Watson
990908.3btw	9/8/1999	Broad	Rutherford	Knob Creek	US 64-74A+	rare	B.T. Watson
990908.4btw	9/8/1999	Broad	Rutherford	West Branch (Mountain Ck)	SR 1351+	patchy common	B.T. Watson
990909.1btw	9/9/1999	Broad	Polk	White Oak Creek	SR 1526-	patchy uncommon	B.T. Watson
990909.3btw	9/9/1999	Broad	Polk	Little White Oak Creek	SR 1322+	patchy common	B.T. Watson
990909.4btw	9/9/1999	Broad	Polk	Machine Creek	SR 1330-	rare	B.T. Watson
990909.5btw	9/9/1999	Broad	Polk	Walnut Creek	SR 1311-	patchy uncommon	B.T. Watson
990909.6btw	9/9/1999	Broad	Rutherford	Broad River	SR 1181+	patchy uncommon	B.T. Watson
990910.1btw	9/10/1999	Broad	Rutherford	Bills Creek	SR 1008-/+	rare	B.T. Watson
990910.2btw	9/10/1999	Broad	Rutherford	Cove Creek	SR 1337-	patchy uncommon	B.T. Watson
990910.3btw	9/10/1999	Broad	Rutherford	Cedar Creek	SR 1008+	rare	B.T. Watson
990910.4btw	9/10/1999	Broad	Rutherford	East Branch (Mountain Ck)	SR 1331-	rare	B.T. Watson
990914.1btw	9/14/1999	Broad	Rutherford	Cathays Creek	SR 1325+	common	B.T. Watson
990914.2btw	9/14/1999	Broad	Rutherford	Holland Creek	SR 1538-	patchy uncommon	B.T. Watson
990915.1btw	9/15/1999	French Broad	Henderson	Bat Fork Creek	SR 1783-/+	patchy uncommon	B.T. Watson
990915.2btw	9/15/1999	Broad	Henderson	Joe Creek	SR 1106+	common	B.T. Watson
990915.3btw	9/15/1999	Broad	Henderson	Freeman Creek	by SR 1115-/+	rare	B.T. Watson
990920.1btw	9/20/1999	Broad	Rutherford	Floyd's Creek	SR 2152-	patchy uncommon	B.T. Watson
990921.1btw	9/21/1999	Broad	Henderson	Green River	SR 1104+	patchy common	B.T. Watson
990921.2btw	9/21/1999	Broad	Henderson	Rock Creek	SR 1106-	patchy common	B.T. Watson

Table 3b (cont). Aquatic snail species found in Green River Game Land and associated waterways.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Ferrissia</i> sp.							
990921.5btw	9/21/1999	Broad	Polk	North Pacolet River	US 176 @ SR 1125-/+	rare	B.T. Watson
990922.1btw	9/22/1999	Broad	Polk	Britten Creek	SR 1158-/+	rare	B.T. Watson
990922.3btw	9/22/1999	Broad	Rutherford	Broad River	US 64-74A @ SR 1184-	patchy uncommon	B.T. Watson
990922.4btw	9/22/1999	Broad	Rutherford	Second Broad River	SR 1602-	rare	B.T. Watson
990922.5btw	9/22/1999	Broad	Henderson	Little Hungry River	SR 1713+	rare	B.T. Watson
990922.6btw	9/22/1999	Broad	Henderson	Big Hungry River	SR 1802-/+	rare	B.T. Watson
<i>Helisoma anceps</i>							
990813.4btw	8/13/1999	Broad	Polk	Green River	SR 1313+	abundant	B.T. Watson
990914.1btw	9/14/1999	Broad	Rutherford	Cathey's Creek	SR 1325+	abundant	B.T. Watson
990914.2btw	9/14/1999	Broad	Rutherford	Holland Creek	SR 1538-	rare	B.T. Watson
990915.1btw	9/15/1999	French Broad	Henderson	Bat Fork Creek	SR 1783-/+	abundant	B.T. Watson
<i>Leptoxis carinata</i>							
990831.3btw	8/31/1999	Broad	Polk	Green River	SR 1302+	present	A.E. Bogan
<i>Micromenetus dilatatus</i>							
990914.1btw	9/14/1999	Broad	Rutherford	Cathey's Creek	SR 1325+	patchy uncommon	B.T. Watson
<i>Physella</i> sp.							
990831.3btw	8/31/1999	Broad	Polk	Green River	SR 1302+	rare	B.T. Watson
990909.1btw	9/9/1999	Broad	Polk	White Oak Creek	SR 1526-	rare	B.T. Watson
990909.2btw	9/9/1999	Broad	Polk	South Branch	NC 9-	patchy uncommon	B.T. Watson
990909.4btw	9/9/1999	Broad	Polk	Machine Creek	SR 1330-	rare	B.T. Watson
990910.1btw	9/10/1999	Broad	Rutherford	Bills Creek	SR 1008-/+	rare	B.T. Watson
990914.1btw	9/14/1999	Broad	Rutherford	Cathey's Creek	SR 1325+	rare	B.T. Watson
990914.2btw	9/14/1999	Broad	Rutherford	Holland Creek	SR 1538-	patchy rare	B.T. Watson
990914.3btw	9/14/1999	Broad	Rutherford	Richardson Creek	SR 1135+	rare	B.T. Watson
990915.1btw	9/15/1999	French Broad	Henderson	Bat Fork Creek	SR 1783-/+	patchy uncommon	B.T. Watson
990920.1btw	9/20/1999	Broad	Rutherford	Floyd's Creek	SR 2152-	patchy uncommon	B.T. Watson
990922.5btw	9/22/1999	Broad	Henderson	Little Hungry River	SR 1713+	rare	B.T. Watson
990922.6btw	9/22/1999	Broad	Henderson	Big Hungry River	SR 1802-/+	rare	B.T. Watson

Table 3b (cont.). Aquatic snail species found in Green River Game Land and associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>River Basin</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<i>Pseudosuccinea columella</i>							
990914.1btw	9/14/1999	Broad	Rutherford	Caltheys Creek	SR 1325+	common	B.T. Watson
990914.3btw	9/14/1999	Broad	Rutherford	Richardson Creek	SR 1135+	rare	B.T. Watson
990915.1btw	9/15/1999	French Broad	Henderson	Bat Fork Creek	SR 1783/+	patchy common	B.T. Watson
<i>Somatogyrus sp.</i>							
990831.3btw	8/31/1999	Broad	Polk	Green River	SR 1302+	patchy common	F.G. Thompson, A.E. Bogan

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CRAYFISHES

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Introduction

Crayfish play important roles in aquatic and sometimes terrestrial ecosystems, both as food sources for many animals and also as consumers of plant and animal material. Despite the magnitude of their ecological roles, we have much to learn about crayfish distributions, life histories, and taxonomy. As part of the inventory of aquatic animals associated with the state-owned Green River Game Land, we conducted field surveys of the crayfishes found in waterways occurring in and around the game land to contribute to our understanding of the distribution and status of crayfishes in North Carolina.

Reproduction and Life History

The crayfishes that occur in North Carolina (all members of the family Cambaridae) live for 2-3 years, on average (Hobbs III 1991, Taylor et al. 1996). Energy obtained from food consumption is allocated largely toward growth as juveniles and toward reproduction as adults (DiStefano 1993). Growth is accomplished through a series of exoskeletal molts (a process known as ecdysis), numbering from 5-10 until adulthood is reached, followed by only 1 (females) or 2 (males) molts per year on average throughout adulthood (Hobbs III 1991, DiStefano 1993). Male cambarid crayfishes exhibit cyclic dimorphism, alternating between a reproductively active form (form I) and a non-reproductive form (form II). Form I males can be present all year, but are usually most abundant during the fall and/or spring. Females carry fertilized eggs attached to their abdomens (a condition that is termed "in berry") for 2-20 weeks, depending on water temperatures. Once hatched, the juveniles are carried on the female until they molt into the 3rd instar (on average), after which they are free-living. Cambarid crayfishes breed more than once during their lives (Hobbs III 1991, DiStefano 1993).

Habitat Requirements and Preferences

Crayfish occur in lentic (e.g., lakes, ponds, marshes, ditches, backwaters of large rivers, groundwater) and lotic (e.g., streams, rivers, groundwater) aquatic habitats ranging from oligotrophic to hypereutrophic (Hobbs III 1991). Crayfish can be further classified as hypogean (below-ground dwellers) or epigean (above-ground dwellers). Hypogean crayfish spend much of their time in elaborate underground burrows associated with groundwater. These burrows can be in close proximity to a water body or stream, but can also be situated far from open water. Depending on the amount of time spent underground and the extent of tunnels created, burrowing crayfish are classified as primary, secondary, or tertiary burrowers (Hobbs III 1991). Generally, epigean crayfish occur in shallow (1-2 m) water, but can occur in deeper water, especially as adults. Juveniles are often found in littoral areas, where adequate shelter provides protection from predation and may mediate competition with adults. Crayfish actively forage at night, but seek shelter from predators during daylight in aquatic macrophytes, leaf litter, woody

debris, overhanging roots, cobble or large boulders, burrows or depressions, and in human debris (e.g., cans, tires) (Lodge and Hill 1994).

Crayfish are affected by both water and habitat quality. Changes in water quality that interfere with respiration (e.g., drastic temperature changes, acidification, pollution) can be detrimental to crayfish populations. Many crayfish are oxygen regulators and can survive changes in oxygen levels (Reiber 1995), but some are oxygen conformers and are less likely to successfully contend with these changes (Hobbs III 1991). Water pollution, caused by sources such as sewage, agricultural and urban runoff, acidification, and auto exhaust, can result in bioaccumulation of pesticides and trace heavy metals (e.g., lead, copper, cadmium). This can harm animals that consume crayfish in addition to directly causing negative effects on crayfish (e.g., mutation, reproductive failure, death) (Taylor et al. 1995, Daveikis and Alikhan 1996, Anderson et al. 1997, Zaranko et al. 1997). Habitat destruction can also negatively affect crayfish populations. Land use practices (e.g., agriculture, logging, development) can alter habitat resulting in fewer areas available as shelter to crayfish (Smith et al. 1996, Richter et al. 1997). For example, siltation and runoff can decrease macrophyte (a source of food and shelter) availability, and channelization can alter stream bed sculpture.

Ecological Interactions

Crayfish are both directly and indirectly linked to the ecosystems in which they live. Because they are omnivorous (i.e., consume both plant and animal food, living or dead), and because they are consumed by animals from various trophic levels, crayfish form multiple links in aquatic and terrestrial food webs (Lodge et al. 1994, Charlebois and Lamberti 1996, Nystrom et al. 1996). Thus, crayfish are involved in the transfer of large amounts of energy in these systems. Crayfish process nutrients and make them available to other animals by (1) breaking down large material via shredding into smaller sizes, and (2) converting nutrients into biomass. Crayfish feed on aquatic vegetation (e.g., macrophytes, algae, periphyton), macroinvertebrates (e.g., aquatic insects, mollusks, small crustaceans), and small vertebrates (e.g., amphibians, small/juvenile fish). Crayfish also consume nonliving organic matter such as leaf litter or terrestrial animal carcasses from the riparian zone or shore and decaying aquatic plant and animal matter (Lodge and Hill 1994). Crayfish in turn are consumed by invertebrates (including other crayfish), fish, amphibians, reptiles, birds, and mammals (Lodge and Hill 1994). Crayfish perform an important role as a member of symbiosis with many invertebrates and as host to various aquatic parasites (Lodge and Hill 1994). Crayfish also experience competition, both between species and among different sizes of individuals within a population (Lodge and Hill 1994).

The introduction of non-indigenous crayfishes to areas currently occupied by native crayfishes can result in competition or even extirpation of natives and can have impacts on other components of the ecosystem (Charlebois and Lamberti 1996, Perry 1998). For example, if crayfish become too abundant, they can be destructive to aquatic ecosystems by destroying more macrophytes than they consume, resulting in less habitat and food for other animals (Lodge et al. 1994, Nystrom et al. 1996). In fact, Lodge et al. (2000) consider nonindigenous crayfish introductions to be the single greatest threat to native crayfish biodiversity worldwide.

Taxonomy, Distribution, and Statuses

In the United States and Canada, approximately 350 taxa of crayfish are recognized (Taylor et al. 1996, J.E. Cooper, NC State Museum of Natural Sciences, Curator of Crustaceans, pers. comm.). However, many species still await description (J.E. Cooper, NCSM, pers. comm.). For example, several current species are now recognized to be species complexes consisting of more than a single taxon. Conversely, animals grouped into several species or subspecies by different authors may actually belong to the same species. The greatest diversity of crayfishes occurs in the Southeast (Hobbs III 1991, Taylor et al. 1996), and North Carolina harbors at least 33 native (possibly up to 46) and 3 introduced species of *Cambarus*, *Procambarus*, *Orconectes*, and *Fallicambarus* (Cooper and Braswell 1995, J.E. Cooper, NCSM, pers. comm.). About half of the described crayfishes in North Carolina are of undetermined conservation status due to a lack of data on the distribution and abundance of these animals. Additionally, there are perhaps as many as a dozen native species yet to be described (J.E. Cooper, NCSM, pers. comm.). Of those species for which we have at least some information, the North Carolina Natural Heritage Program lists 10 species as significantly rare (LeGrand and Hall 1998), and the Scientific Council on Freshwater and Terrestrial Crustaceans proposes that 8 of North Carolina's species be of special concern, and that 13 species be put on a watch list (Clamp 1999). New information about current distributions has recently been reported (Cooper and Braswell 1995, Cooper et al. 1998). However, given that undescribed species exist and that we have much to learn about the distributions of crayfishes in North Carolina, it is imperative that we continue to improve our knowledge of crayfish by contributing to the growing database.

Methods

The crayfish survey of Green River Game Land was conducted during the summer and fall of 1999. Refer to the Report Introduction for details on history of land use, drainage basin and waterway descriptions, and a map of all the sites that were surveyed. Waterways were accessed at bridge crossings, from roads running alongside rivers, or by canoe. For smaller streams, we generally sampled upstream for an arbitrary distance (usually about 30 minutes of walking), until we felt that we had covered most habitat types present. For rivers and larger streams, we often snorkeled upstream starting at various points along the river. Typical distances were 100 - 400 meters.

Crayfishes were collected using a number of different techniques, depending on the conditions of the waterway being sampled (e.g., substrate type, width/depth of water). When snorkeling, crayfishes were collected by hand or with small dip nets after turning over or disturbing rocks under which they were hiding. When not snorkeling, we used both small and large dip nets to capture crayfishes after overturning rocks. We also sampled stream edges and leaf litter piles for juveniles and for species preferring slower habitats. Finally, we collected crayfishes by electrofishing while sampling for fishes. Electrofishing proved to be a less successful method for collecting crayfishes than visual location and dip netting. Collected specimens were preserved and stored in 70%-denatured ethanol.

Successful identification of many cambarid crayfishes usually requires collection of reproductive (form I) males. Certain features of their gonopods – the first pair of abdominal appendages, or pleopods – can be important in their taxonomy. Form I males can be distinguished from form II

males by the advanced development of the terminal elements at the tips of their gonopods. In addition, form I males have highly developed hooks on the ischia of certain walking legs (pereiopods) that are used to hold the female during copulation. The size and shape of their chelae may also vary at this stage. Some common characteristics used in identification of non-form I males are carapace length and depth/width ratio, areola width and length, presence and placement of spines, rostrum shape, color, and chela characteristics. Identification of crayfishes was accomplished through the use of taxonomic keys (Hobbs Jr. 1991, Jezerinac et al. 1995) and a checklist (Hobbs Jr. 1989), by comparing individuals to reference collection specimens (North Carolina Wildlife Resources Commission and North Carolina State Museum of Natural Sciences), and via personal communication with Dr. J.E. Cooper. Common names are according to Clamp (1999). As our understanding of crayfish taxonomy continues to improve, the identifications of the species we collected may change.

In addition to identifying individuals, we noted approximate abundances of each type of crayfish collected, and quantified average carapace lengths of those collected (from the tip of the rostrum to the posterior carapace edge). We also looked for evidence of recent reproduction and estimated habitat preferences of each species based on the areas from which they were collected. We recorded presence/absence data for each species encountered at each site visited to allow a crude estimate of the distribution of each species within the waterways associated with the game lands. These data will also be added to a larger database describing statewide distributions. Where possible, we recorded notes on ecological interactions (e.g., abundance of food, presence of competitors or predators, quality of habitat). For logistical and ethical reasons, we did not preserve every crayfish collected.

Results

Over 21 days from 10 August to 27 October 1999, 57 sites were inventoried (sites 24 and 25 were surveyed for mollusks only; sites 21 and 22 were surveyed for crayfish but the specimens were included with those from site 20) and crayfish were collected or observed at 53 sites (Figure 4 and Table 4a). Crayfish were not observed at 4 sites. Six species were collected during the survey period: *Cambarus* (*Cambarus*) sp. A (may be conspecific with *C. (C.) howardi* Hobbs and Hall, 1969), *Cambarus (C.) bartonii* (Fabricius, 1798), *Cambarus (C.) lenati* Cooper, 2000, *Cambarus (Jugicambarus) asperimanus* Faxon, 1914, *Cambarus (Puncticambarus)* sp. C (a species complex related to *C. (P.) acuminatus* Faxon, 1884, and likely containing at least 2 species in this survey), and *Orconectes (Procericambarus) rusticus* (Girard, 1852), an introduced species. See Table 4b for statistics on carapace lengths of each species collected.

Cambarus (C.) sp. A (Chattahoochee crayfish) was most commonly found hiding under rocks in fast flowing water. The size of crayfish collected was directly related to the size of rock it was found under, with larger crayfish preferring larger rocks. Juveniles were found along stream edges in leaf litter piles and backwater areas, but also under small rocks in the center of streams. This species was common in most waterways surveyed, and was especially abundant in larger streams or rivers. The presence of many juveniles of various sizes indicated that recent and fairly continuous reproduction was occurring. This is not surprising, as this species spends most of its life above-ground. Crayfish assigned to this species may be synonymous with *C. (C.) howardi*. Most animals were light tan or green in color with scarlet abdominal sutures and rostral margins, and lacking complicated patterns. One female collected from the upper Green

River was powder blue in living color. This species occurs on the proposed watch list (Clamp 1999).

Cambarus (C.) bartonii (Appalachian brook crayfish) was found only in the 1 stream that was surveyed in the French Broad River Basin. Its habitat was similar to that of *C. (C.)* sp. A – it preferred faster areas and was found under rocks. The taxonomic designation *C. (C.) bartonii* likely contains multiple species yet to be described. These animals were dark brown in color.

Cambarus (C.) lenati (Broad River stream crayfish) was collected from several locations and was uncommon to common. This species was recently described from the First Broad River drainage (Cooper 2000), which is just east of the areas we surveyed. The specimens we collected thus expand the known range of this species. This species can be distinguished from other members of its subgenus primarily by its different reproductive structures (male and female), but otherwise looks very similar to *C. (C.)* sp. A.

Cambarus (J.) asperimanus (no common name available) was collected from 4 sites. Live crayfish were collected from 3 sites, and chelae were collected from the fourth. Only 1 or 2 individuals were collected at each site, and all sites were steep gradient headwaters of large rivers (Green River, North Pacolet River, and Cove Creek – a major tributary to the Green River). Crayfish were collected from under rocks in fast-flowing areas only, and appeared to be quite aggressive when captured. The first-form male collected from the North Pacolet River was brick red in color, whereas the others were chocolate brown.

Cambarus (P.) sp. C. (no common name available) was found in various types of habitat. Some were found hiding under rocks in fast flowing water, and some were found in leaf litter piles or along stream edges. Juveniles were found along stream edges in leaf litter piles and backwater areas. This species complex was common in many waterways surveyed. The presence of many juveniles of various sizes indicated that recent and fairly continuous reproduction was occurring, which is not surprising, as members of this species complex spend most of their lives above-ground.

There appear to be at least 2 forms of this species complex (possibly several different species). One form closely resembles *C. (P.) reburus* (French Broad crayfish) – a species that is currently known to occur only in the French Broad and upper Savannah river basins – with its long narrow rostrum, obsolete suborbital angle, narrow chelae, wide areola, and strong spines. Many individuals also possessed the characteristic double row of stripes on the dorsal abdomen, whereas others had a more mottled saddle pattern that was brightly colored and quite striking. Individuals of this form were collected only from slow flow areas in leaf litter piles or along stream edges, concurrent with known habitat preferences of *C. (P.) reburus*. The other form(s) does not differ as much from other members of the complex, having a shorter and wider rostrum, acute suborbital angle, wide chelae, narrower areola, and less strong spines than the aforementioned form. These individuals had either a dull solid color or a dull mottled saddle pattern. Individuals of this form were collected primarily from fast-flowing areas in stream centers, hiding under rocks. Further taxonomic investigation that is currently underway should clarify the identity of these 2 forms.

Orconectes (P.) rusticus (rusty crayfish), an introduced species, was collected from 2 sites in the Broad River, below Lake Lure. At both sites, it was by far the most abundant species collected. Many sizes and all reproductive forms were present, including a large range in size of form I males. Crayfish were collected from all habitat types: they were found under rocks in high flow areas as well as along edges and in backwater areas. At one site, many crayfish were collected from a temporary pool. Most crayfish were found under rocks in an intermediate flow area. This species can be readily recognized by 2 rust-colored spots on the posterior sides of the carapace, as though it were picked up with paint-covered fingertips. In addition, its chelae are generally tipped in orange-red, followed by a strong black band closer to the body. Its rostrum is distinctly concave and scoop-like, and the cutting edges of its mandibles are smooth (rather than serrated, like most crayfishes). The individuals we collected were bluish-gray in color, fading to brown in areas, with dark coloring on the dorsal abdomen, and with light blue or whitish legs.

Discussion

The overall diversity of crayfish in this system was high, largely due to the high abundance and distribution of *C. (C.)* sp. A and *C. (P.)* sp. C, and the presence of a number of other species. Distributions of *C. (J.) asperimanus* and *C. (C.) lenati* were limited to only a few waterways, with *C. (J.) asperimanus* being rare at each site, and *C. (C.) lenati* being uncommon to common. *C. (C.)* sp. A and *C. (P.)* sp. C were fairly widespread, and occurred with most other species at sites where they were collected. *C. (J.) asperimanus* was collected with *C. (C.)* sp. A at 4 sites, and with *C. (P.)* sp. C at 1 site. *C. (C.) lenati* was collected with *C. (P.)* sp. C, *O. (P.) rusticus*, and at 1 site with *C. (C.)* sp. A. The introduced crayfish, *O. (P.) rusticus*, occurred at 2 sites, each time with only a few individuals of *C. (C.) lenati*. At 4 sites, we collected no crayfish. This may be because of difficult sampling conditions, rather than due to a lack of crayfish present.

Aspects of crayfish communities can tell us something about the system in which they occur. Although we did not directly test water quality, it was clear that the conditions in Green River Game Land were favorable to support crayfish (at least these species) in most of the waterways sampled. Further, current reproduction was evident. Potential food sources (e.g., allochthonous and autochthonous organic debris, aquatic insects) were abundant, and abundant vegetation was present. Crayfishes were rarely seen away from cover. Predation pressure on these crayfishes (especially juveniles) was likely high because the fish community in this system was healthy (see *Fish* section of this report). However, plenty of cover-providing habitat (mostly large rocks) was available to crayfishes and likely lessened direct impact by predation. It is unclear whether any of the less widespread species were limited by competition or by abiotic factors such as low dissolved oxygen or high acidity.

O. (P.) rusticus was likely introduced into Lake Lure as fishing bait and has spread downstream in the river. This species is native to tributaries of the Ohio River in parts of Ohio, Indiana, and Kentucky. It has since invaded much of Wisconsin, Michigan, and parts of many other states, including Tennessee (Perry 1998). This is the first record of its occurrence in North Carolina. This species is considered to be an extremely dangerous invader because it is aggressive and competes with native crayfish and other organisms. It competes directly for food, and it destroys aquatic plants that are used as food and shelter by other animals (Perry 1998). It is known to be tolerant to poor conditions, and thus has a broader area of habitat available to it than native species. It is unclear whether the rusty crayfish has had any deleterious effects on native

crayfishes at these 2 locations because this has not been adequately studied. However, it was very abundant at both sites, and only a few other individuals of 1 endemic species were collected concurrently, which suggests that it may already be having an impact on native crayfishes.

We found 5 of the 6 species historically known to occur in the Broad River Basin, including a newly described species. We also found 1 exotic species. We did not collect any individuals of *Cambarus (P.) spicatus* (Broad River spiny crayfish), a species known from 2 locations in this river basin: (1) headwaters of the North Pacolet River in Polk County, and (2) the First Broad River in Cleveland County. It may be very rare, but it could also be a habitat specialist or its distribution could be very localized, occurring only in areas where we did not sample. Current records do not indicate the presence of any burrowing species in this river basin, and we did not find any (although our methods were not designed to look for burrowers). *C. (D.) reduncus*, primarily a burrowing species, may occur in this river basin but has yet to be confirmed (J.E. Cooper, NCSM, pers. comm.). This survey has helped to further clarify distribution boundaries of several species in the Broad River Basin. It has also informed us of the presence of a potentially very dangerous exotic crayfish in the Broad River.

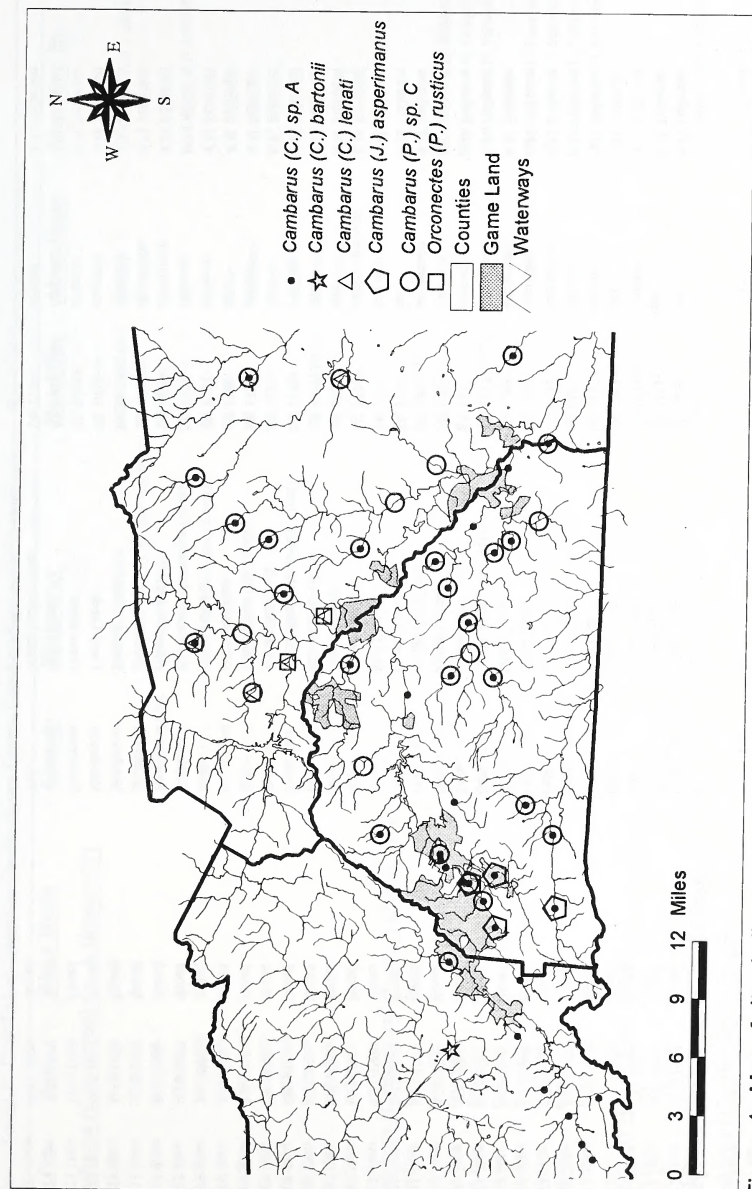


Figure 4. Map of sites indicating where each species of crayfish was collected in the Green River Game Land aquatic inventory, Henderson, Polk, and Rutherford counties, North Carolina, 1999.

Table 4a. Crayfishes found in Green River Game Land and associated waterways. See text for common names.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Cambarus (Cambarus) bartonii</i>							
990915.1btw	9/15/1999	French Broad	Henderson	Bat Fork Creek	SR 1783+/-	common	A.H. Fullerton
991012.1btw	10/12/1999	French Broad	Henderson	Bat Fork Creek	SR 1783+/-	common	A.H. Fullerton
<i>Cambarus (Cambarus) sp. A [Howard?]</i>							
990810.2btw	8/10/1999	Broad	Polk	Cove Creek	SR 1142	present	A.H. Fullerton
990811.1btw	8/11/1999	Broad	Polk	Green River	SR 1151-	abundant	A.H. Fullerton
990811.2btw	8/11/1999	Broad	Polk	Green River	SR 1151+/-	common	A.H. Fullerton
990811.3btw	8/11/1999	Broad	Polk	Cove Creek	SR 1151+/-	rare	A.H. Fullerton
990812.1btw	8/12/1999	Broad	Polk	Green River	SR 1151-	uncommon	A.H. Fullerton
990812.2btw	8/12/1999	Broad	Polk	Laurel Branch	SR 1151-	abundant	A.H. Fullerton
990812.3btw	8/12/1999	Broad	Polk	Gadd Creek	SR 1151-	rare	A.H. Fullerton
990813.1btw	8/13/1999	Broad	Polk	Cove Creek	SR 1142+	abundant	A.H. Fullerton
990813.2btw	8/13/1999	Broad	Polk	Ostin Creek	SR 1142+/-	uncommon	A.H. Fullerton
990830.1btw	8/30/1999	Broad	Polk	Green River	SR 1313+	uncommon	A.H. Fullerton
990830.2btw	8/30/1999	Broad	Polk	Green River	SR 1331+	uncommon	A.H. Fullerton
990831.1btw	8/31/1999	Broad	Polk	Wheat Creek	SR 1329+	common	J.E. Cooper, A.H. Fullerton
990831.3btw	8/31/1999	Broad	Polk	White Oak Creek	SR 1005-	uncommon	A.H. Fullerton
990831.5btw	8/31/1999	Broad	Polk	Green River	SR 1302+	rare	A.H. Fullerton
990901.1btw	9/1/1999	Broad	Polk	Mill Creek	SR 1339-	common	A.H. Fullerton
990901.2btw	9/2/1999	Broad	Polk	Green River	SR 1005 +/-	patchy common	A.H. Fullerton
990908.3btw	9/8/1999	Broad	Rutherford	Knob Creek	US 64-74A+	rare	A.H. Fullerton
990908.4btw	9/8/1999	Broad	Rutherford	West Branch (Mountain Creek)	SR 1351+	common	A.H. Fullerton
990909.1btw	9/9/1999	Broad	Polk	White Oak Creek	SR 1526-	rare	A.H. Fullerton
990909.3btw	9/9/1999	Broad	Polk	Little White Oak Creek	SR 1322+	present	A.H. Fullerton
990909.4btw	9/9/1999	Broad	Polk	Machine Creek	SR 1330-	rare	A.H. Fullerton
990909.5btw	9/9/1999	Broad	Polk	Walnut Creek	SR 1311-	common	A.H. Fullerton
990910.4btw	9/10/1999	Broad	Rutherford	East Branch (Mountain Creek)	SR 1331-	common	J.E. Cooper, A.H. Fullerton
990914.4btw	9/14/1999	Broad	Rutherford/Polk	Henson Creek	SR 1300-	uncommon	A.H. Fullerton
990915.2btw	9/15/1999	Broad	Henderson	Joe Creek	SR 1106+	uncommon	A.H. Fullerton
990915.3btw	9/15/1999	Broad	Henderson	Freeman Creek	by SR 1115+/-	common	A.H. Fullerton
990915.5btw	9/15/1999	Broad	Henderson	Camp Creek	SR 1836+/-	common	A.H. Fullerton
990921.1btw	9/21/1999	Broad	Henderson	Green River	SR 1104+	common	A.H. Fullerton
990921.3btw	9/21/1999	Broad	Henderson	Bob's Creek	SR 1101/1104-	common	A.H. Fullerton
990921.4btw	9/21/1999	Broad	Polk	North Paolier River	US 176-	present	A.H. Fullerton

Table 4a (cont.). Crayfishes found in Green River Game Land and associated waterways. See text for common names.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Cambarus (Cambarus) sp. A [howardi?]</i>							
990921.3bw	9/21/1999	Broad	Polk	North Pacolet River	US 176/SR1125+/-	common	J.E. Cooper, A.H. Fullerton
990922.2bw	9/22/1999	Broad	Polk	Unnamed tributary to Lake Adger	SR 1156+/-	common	A.H. Fullerton
990922.6bw	9/22/1999	Broad	Henderson	Big Hungry River	SR 1802+/-	rare	A.H. Fullerton
990923.2bw	9/23/1999	Broad	Polk	Green River	SR 1331+/-	rare	A.H. Fullerton
991011.2bw	10/11/1999	Broad	Rutherford	East Branch (Mountain Creek)	SR 1331-	rare	A.H. Fullerton
991011.6bw	10/11/1999	Broad	Rutherford	Cedar Creek	SR 1008-	present	A.H. Fullerton
991012.2bw	10/12/1999	Broad	Henderson	Green River	SR 1104+	uncommon	A.H. Fullerton
991012.3bw	10/12/1999	Broad	Henderson	Rock Creek	SR 1106-	present	A.H. Fullerton
991012.4bw	10/12/1999	Broad	Henderson	Joe Creek	SR 1106-	present	A.H. Fullerton
991012.5bw	10/12/1999	Broad	Polk	North Pacolet River	US 176/SR1125+/-	uncommon	A.H. Fullerton
991026.1bw	10/26/1999	Broad	Rutherford	Floyd's Creek	SR 2152+	uncommon	A.H. Fullerton
991027.3bw	10/27/1999	Broad	Polk	Ostin Creek	SR 1142-	rare	A.H. Fullerton
<i>Cambarus (Cambarus) cf. sp. A [howardi?]</i>							
990908.2bw	9/8/1999	Broad	Rutherford	Maple Creek	by SR 1178 +/-	uncommon	A.H. Fullerton
990914.1bw	9/14/1999	Broad	Rutherford	Cathey's Creek	SR 1325+	common	J.E. Cooper, A.H. Fullerton
990914.3bw	9/14/1999	Broad	Rutherford	Richardson Creek	SR 1135+	common	J.E. Cooper, A.H. Fullerton
990915.4bw	9/15/1999	Broad	Henderson	Tributary to Green River	US 176 (beside)+	common	J.E. Cooper, A.H. Fullerton
990920.1bw	9/20/1999	Broad	Rutherford	Floyd's Creek	SR 2152-	uncommon	A.H. Fullerton
990921.2bw	9/21/1999	Broad	Henderson	Rock Creek	SR 1106-	common	J.E. Cooper, A.H. Fullerton
990921.6bw	9/21/1999	Broad	Polk	Skyuka Creek	SR 1135-	uncommon	J.E. Cooper, A.H. Fullerton
990922.4bw	9/22/1999	Broad	Rutherford	Second Broad River	SR 1602-	common	J.E. Cooper, A.H. Fullerton
991011.4bw	10/11/1999	Broad	Rutherford	Knob Creek	US 64-74A+	rare	J.E. Cooper, A.H. Fullerton
<i>Cambarus (Cambarus) lenati</i>							
990909.6bw	9/9/1999	Broad	Rutherford	Broad River	SR 1181+	rare	A.H. Fullerton
990910.3bw	9/10/1999	Broad	Rutherford	Cedar Creek	SR 1008+	uncommon	A.H. Fullerton
990922.3bw	9/22/1999	Broad	Rutherford	Broad River	US 64-74A/SR 1184-	rare	J.E. Cooper, A.H. Fullerton
<i>Cambarus (Cambarus) cf. lenati</i>							
990910.1bw	9/10/1999	Broad	Rutherford	Bills Creek	SR 1008+/-	common	J.E. Cooper, A.H. Fullerton
990914.2bw	9/14/1999	Broad	Rutherford	Holland Creek	SR 1538-	uncommon	A.H. Fullerton

Table 4a (cont.). Crayfishes found in Green River Game Land and associated waterways. See text for common names.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Cambarus (Jugicambarus) asperimanus</i>							
990811.1btw	8/11/1999	Broad	Polk	Green River	SR 1151-	present	A.H. Fullerton
990811.3btw	8/11/1999	Broad	Polk	Cove Creek	SR 1151+/-	rare	A.H. Fullerton
990813.1btw	8/13/1999	Broad	Polk	Cove Creek	SR 1142+	rare	A.H. Fullerton
990921.4btw	9/21/1999	Broad	Polk	North Pascolet River	US 176-	uncommon	A.H. Fullerton
<i>Cambarus (Punciticambarus) sp. C</i>							
990811.2btw	8/11/1999	Broad	Polk	Green River	SR 1151+/-	common	A.H. Fullerton
990811.3btw	8/11/1999	Broad	Polk	Cove Creek	SR 1151+/-	rare	A.H. Fullerton
990830.2btw	8/30/1999	Broad	Polk	Wheat Creek	SR 1329+	abundant	J.E. Cooper, A.H. Fullerton
990831.1btw	8/31/1999	Broad	Polk	White Oak Creek	SR 1005-	common	A.H. Fullerton
990831.2btw	8/31/1999	Broad	Polk	Green River	SR 1340+	common	A.H. Fullerton
990831.4btw	8/31/1999	Broad	Rutherford	Cleghorn Creek	SR 1149-	uncommon	A.H. Fullerton
990831.5btw	8/31/1999	Broad	Polk	Mill Creek	SR 1339-	common	A.H. Fullerton
990901.1btw	9/1/1999	Broad	Polk	Green River	SR 1151+	patchy uncommon	A.H. Fullerton
990908.1btw	9/8/1999	Broad	Rutherford	Mountain Creek	NC 108+/-	uncommon	A.H. Fullerton
990908.2btw	9/8/1999	Broad	Rutherford	Maple Creek	by SR 1178 +/-	uncommon	A.H. Fullerton
990908.3btw	9/8/1999	Broad	Rutherford	Knob Creek	US 64-74A+	common	A.H. Fullerton
990908.4btw	9/8/1999	Broad	Rutherford	West Branch (Mountain Creek)	SR 1351+	common	A.H. Fullerton
990909.1btw	9/9/1999	Broad	Polk	White Oak Creek	SR 1526-	common	A.H. Fullerton
990909.2btw	9/9/1999	Broad	Polk	South Branch	NC 9-	common	A.H. Fullerton
990909.3btw	9/9/1999	Broad	Polk	Little White Oak Creek	SR 1322+	present	A.H. Fullerton
990909.4btw	9/9/1999	Broad	Polk	Machine Creek	SR 1330-	rare	A.H. Fullerton
990909.5btw	9/9/1999	Broad	Polk	Walnut Creek	SR 1311-	common	A.H. Fullerton
990910.1btw	9/10/1999	Broad	Rutherford	Bills Creek	SR 1008+/-	common	J.E. Cooper, A.H. Fullerton
990910.2btw	9/10/1999	Broad	Rutherford	Cove Creek	SR 1337-	present	A.H. Fullerton
990910.3btw	9/10/1999	Broad	Rutherford	Cedar Creek	SR 1008+	common	A.H. Fullerton
990910.4btw	9/10/1999	Broad	Rutherford	East Branch (Mountain Creek)	SR 1331-	common	J.E. Cooper, A.H. Fullerton
990914.1btw	9/14/1999	Broad	Rutherford	Caldeys Creek	SR 1325+	common	J.E. Cooper, A.H. Fullerton
990914.2btw	9/14/1999	Broad	Rutherford	Holland Creek	SR 1538-	common	A.H. Fullerton
990914.3btw	9/14/1999	Broad	Rutherford	Richardson Creek	SR 1135+	common	J.E. Cooper, A.H. Fullerton
990914.4btw	9/14/1999	Broad	Rutherford/Polk	Henson Creek	SR 1300-	common	A.H. Fullerton
990920.1btw	9/20/1999	Broad	Rutherford	Floyd's Creek	SR 2152-	common	A.H. Fullerton
990921.5btw	9/21/1999	Broad	Polk	North Pascolet River	US 176/SR 1125+/-	uncommon	J.E. Cooper, A.H. Fullerton
990921.6btw	9/21/1999	Broad	Polk	Skyuka Creek	SR 1135-	common	J.E. Cooper, A.H. Fullerton

Table 4a (cont.). Crayfishes found in Green River Game Land and associated waterways. See text for common names.

<u>Site No.</u>	<u>Date</u>	<u>River Basin</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<i>Cambarus (Punciticambarus) sp. C</i>							
990922.1btw	9/22/1999	Broad	Polk	Britten Creek	SR 1158+/-	present	A.H. Fullerton
990922.2btw	9/22/1999	Broad	Polk	Unnamed tributary to Lake Adger	SR 1156+/-	uncommon	A.H. Fullerton
990922.4btw	9/22/1999	Broad	Rutherford	Second Broad River	SR 1602-	common	J.E. Cooper, A.H. Fullerton
990923.2btw	9/23/1999	Broad	Polk	Green River	SR 1331+/-	rare	A.H. Fullerton
991011.1btw	10/11/1999	Broad	Rutherford	Second Broad River	SR 1602-	common	A.H. Fullerton
991011.2btw	10/11/1999	Broad	Rutherford	East Branch (Mountain Creek)	SR 1331-	common	A.H. Fullerton
991011.3btw	10/11/1999	Broad	Rutherford	West Branch (Mountain Creek)	SR 1351+	present	A.H. Fullerton
991011.4btw	10/11/1999	Broad	Rutherford	Knob Creek	US 64-74A+	common	J.E. Cooper, A.H. Fullerton
991011.5btw	10/11/1999	Broad	Rutherford	Cove Creek	SR 1337-	rare	J.E. Cooper, A.H. Fullerton
991011.6btw	10/11/1999	Broad	Rutherford	Cedar Creek	SR 1008-	present	A.H. Fullerton
991012.5btw	10/12/1999	Broad	Polk	North Pacolet River	US 176/SR1125+/-	uncommon	A.H. Fullerton
991026.1btw	10/26/1999	Broad	Rutherford	Floyd's Creek	SR 2152+	rare	A.H. Fullerton
991026.2btw	10/26/1999	Broad	Rutherford	Richardson Creek	SR 1135-	common	J.E. Cooper, A.H. Fullerton
991026.3btw	10/26/1999	Broad	Polk	Machine Creek	SR 1330-	uncommon	A.H. Fullerton
991026.4btw	10/26/1999	Broad	Polk	White Oak Creek	SR 1526-	common	A.H. Fullerton
991027.1btw	10/27/1999	Broad	Henderson	Big Hungry River	SR 1802+/-	rare	A.H. Fullerton
<i>Orconectes (Procericambarus) rusticus</i>							
990909.6btw	9/9/1999	Broad	Rutherford	Broad River	SR 1181+	abundant	J.E. Cooper, A.H. Fullerton
990922.3btw	9/22/1999	Broad	Rutherford	Broad River	US 176/SR1125+/-	common	A.H. Fullerton
991027.5btw	10/27/1999	Broad	Rutherford	Broad River	SR 1181+	rare	J.E. Cooper, A.H. Fullerton

Table 4b. Statistics on carapace lengths of crayfishes found in Green River Game Land and associated waterways. See text for common names.

<i>Cambarus (Cambarus) bartonii</i>					
female (9 records)	Avg	Std	Min	Max	
	14.4	8.0	8.0	32.5	
male II (6 records)	12.4	1.0	11.0	14.0	
Species Total (15 records)	13.6	6.2	8.0	32.5	
<i>Cambarus (Cambarus) sp. A [howardi?]</i>					
female (128 records)	Avg	Std	Min	Max	
	18.7	9.3	5.5	45.5	
male I (5 records)	33.8	6.5	27.0	43.0	
male II (97 records)	18.0	7.9	5.5	37.0	
Species Total (230 records)	18.7	8.9	5.5	45.5	
<i>Cambarus (Cambarus) cf. sp. A [howardi?]</i>					
female (40 records)	Avg	Std	Min	Max	
	19.2	6.7	6.0	34.5	
male I (2 records)	34.0	9.9	27.0	41.0	
male II (29 records)	16.7	5.5	6.0	34.0	
Species Total (71 records)	18.6	6.9	6.0	41.0	
<i>Cambarus (Cambarus) lenati</i>					
female (6 records)	Avg	Std	Min	Max	
	17.3	5.2	7.5	22.0	
male I (1 record)	39.0		39.0	39.0	
male II (3 records)	22.2	5.8	17.0	28.5	
Species Total (10 records)	20.9	8.3	7.5	39.0	
<i>Cambarus (Cambarus) cf. lenati</i>					
female (7 records)	Avg	Std	Min	Max	
	13.6	6.0	5.5	19.5	
male II (8 records)	18.8	6.4	7.5	29.0	
Species Total (15 records)	16.4	6.6	5.5	29.0	
<i>Cambarus (Jugicambarus) asperimanus</i>					
female (2 records)	Avg	Std	Min	Max	
	22.5	3.5	20.0	25.0	
male I (1 record)	28.0		28.0	28.0	
male II (1 record)	21.0		21.0	21.0	
Species Total (4 records)	23.5	3.7	20.0	28.0	

Table 4b (cont.). Statistics on carapace lengths of crayfishes found in Green River Game Land and associated waterways. See text for common names.

<i>Cambarus (Puncticambarus) sp. C</i>					
female (148 records)	Avg	Std	Min	Max	
male I (3 records)	17.1	7.2	5.0	41.0	
male II (141 records)	33.3	3.2	31.0	37.0	
Species Total (292 records)	16.9	5.8	6.0	38.0	
	17.2	6.7	5.0	41.0	
<i>Orconectes (Procericambarus) rusticus</i>					
female (17 records)	Avg	Std	Min	Max	
male I (17 records)	25.0	5.7	16.5	35.5	
male II (1 record)	24.3	6.3	17.0	39.5	
Species Total (35 records)	21.0		21.0	21.0	
	24.5	5.9	16.5	39.5	

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FRESHWATER FISHES

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Introduction

Fishes are the most numerous and diverse of the major vertebrate groups. Their various morphological, behavioral, reproductive, and physiological adaptations have allowed them to dominate the waters of the world. Fishes can be found in a broad array of habitats, including vernal pools, mountain streams, and the ocean floor. Their dominance is reflected in the number of living species. Over 24,600 species have been described (Moyle and Cech 1996), and it is believed that this number may increase to approximately 28,500 (Nelson 1994). The North American continent harbors approximately 1,100 species of freshwater fish (Burr and Mayden 1992), with 790 (75%) species occurring in the United States (Page and Burr 1991). Nearly 200 native species can be found in North Carolina (Menhinick 1991).

While most of the attention from the public and fisheries biologists is directed towards the game fishes, these species make up only about 5% of the freshwater fish fauna in the United States. The remaining 95% are little known, but charismatic, nongame species, such as darters and minnows. Nongame fishes play a vital role in the balance of aquatic ecosystems. Their diets are diverse, and, in turn, they serve as dietary components for sport fishes, water birds, and other wildlife. They also are important indicators of water quality and can signal when aquatic ecosystems are being negatively impacted. Game fishes also are important components of aquatic ecosystems and provide a source of recreation and employment for many people. Unfortunately, in 1989, the American Fisheries Society regarded 364 North American freshwater fish species as endangered, threatened, or special concern, an increase of 45% in just 10 years (Williams et al. 1989). This number represents approximately one-third of the North American native freshwater fish fauna. Likewise, the southern United States, which supports more native fishes than any comparable size on the North American continent north of Mexico, has experienced a 75% increase in jeopardized fishes since 1989 and a 125% increase in 20 years (Warren et al. 2000). In North Carolina, approximately 25% of the freshwater fishes are state listed. Some of the reasons for this decline include habitat alteration and loss, chemical pollution, overexploitation, and introduction of exotic species. Given this information, it is essential that we better understand the taxonomy, distribution, and conservation needs of the various taxa. Therefore, a freshwater fish inventory of the waterways in and around the state-owned Green River Game Land was initiated to ascertain some of this needed information.

Methods

The freshwater fish survey of Green River Game Land was conducted during the summer and fall of 1999. Refer to the Report Introduction for details on history of land use, drainage basin and waterway descriptions, and a map of all the sites that were surveyed. Waterways were accessed at bridge crossings, from roads running alongside rivers, or by canoe. We generally

sampled upstream for an arbitrary distance (usually about 30 minutes of walking), until we felt that we had covered most habitat types present. Typical distances were 100 - 400 meters.

Freshwater fishes were collected using a variety of techniques depending on the conditions of the site being surveyed (e.g., water depth, visibility, substrata types). The most common method used was backpack electrofishing (32 of 57 sites). This method was chosen because it is more comprehensive and efficient than other methods used to collect fishes in streams. The other commonly used technique incorporated into the survey included the use of dip nets. Fish genus and/or species were noted during snorkeling as well. Most fishes collected were identified to species and released unharmed. However, it was necessary to perform some of the identifications in the laboratory. This was carried out by fixing the fish in 10% formalin and preserving them in 70% ethanol. Once the fishes were preserved, they were identified with the use of a compound microscope (Nikon). Fishes were identified according to Menhinick (1991), Page and Burr (1991), Rhode et al. (1994), and Jenkins and Burkhead (1994). Dr. Wayne C. Starnes and others (G.M. Hogue, T.L. Fullbright, and Dr. M.E. Raney) from the NC State Museum of Natural Sciences verified some of the identifications. Besides presence-absence data, relative abundance and recent reproduction information were noted for each species to determine population health.

Results

Over 20 days from 11 August to 27 October 1999, 57 sites were surveyed (sites 24, 25, and 28 were primarily searched for mollusks; see below regarding site 22) and fish were collected or observed at 56 of these localities (Figure 5). *Morone chrysops* was sighted while canoeing at site 22 bringing the total number of sites where fish were observed to 57, but since this site was not sampled for fish in particular, it was not included as a site surveyed. Forty-two species representing 9 families were documented during the survey of Green River Game Land (Tables 5a and 5b). Of the approximately 76 species that have been documented in the vicinity of the survey area within Henderson, Polk, and Rutherford counties (Menhinick 1991), we confirmed the presence of only 39 of these species. Limitations as to our access to all available habitats and sampling range within the 3 counties were the most likely reasons for the absence of particular species. For example, a fair number of the species documented in Henderson County are located near the western county line (e.g., *Etheostoma blennioides*, *E. jessiae*, etc.), while we only surveyed near the eastern side of the county. Elimination of these species would result in the collection of nearly 70% of the documented fish species (Menhinick 1991) from the area. While we did not document the presence of all these species, we did collect 3 species that have yet to be documented from the area (Menhinick 1991): *Esox niger* (chain pickerel), *Lepomis cyanellus* (green sunfish), and *Pylodictis olivaris* (flathead catfish). Overall, abundance, distribution, and recent reproduction were highly variable depending on the species encountered.

Since not all specimens were preserved for laboratory or museum identification, we have chosen to classify some records to genus including the likely species, and some records to genus only. Identifications listed to genus with sp. or spp. as the species designate (e.g., *Notropis* spp.), reflect that these specimens were seen while snorkeling and a species could not be determined (except for *Scartomyzon* sp. = brassy jumprock). Identifications with a single genus and multiple species reflect that these specimens were identified in the field but may not be correct (e.g., *Cyprinella labrosalzanema*). The first species listed is most likely the correct identification

based on our initial naming and current distributions. Likewise, we listed a number of catostomid records in a similar manner. Nearly all of the *Moxostoma* and *Scartomyzon* records that were field identified have been listed as either of the genera. The sp. designate after *Scartomyzon* refers to the brassy jumprock, and after *Moxostoma* indicates the v-lip redhorse but still recognizes the potential for other redhorse species. As before, the initial listing is most likely the correct identification based on our initial identifications and current distributions.

Discussion

The waterways associated with Green River Game Land contain a moderate diversity and distribution of fish species. While some of the fish species were collected at isolated locations (e.g., *Cyprinella nivea*, *Notropis spectrunculus*, and *Lepomis gibbosus*), the majority tended to occur over a moderate to broad area. The species abundance tended to vary among sites, with the cyprinids comprising the majority of the biomass at most of the sites. Likewise, a number of sites were dominated by catostomids. The moderate distribution and abundance of a majority of the species has probably been aided by the relative lack of impacts on the waterways in the area. Overall, the area we surveyed was mostly rural and undeveloped, minimizing the effects of agriculture and urbanization. Compared to other surveys of the area, we appear to have collected a representative sample of the fish fauna. Simon (1995) summarized that 35 fish species have been collected in surveys of the Green River. We indicated the presence of 29 of these species. The absence of any species is more likely due to sampling effort and access than to their extirpation from the Green River. Likewise, our comparisons to Menhinick (1991) reflect that the species composition reported herein is representative of the area as well.

The collections of *Esox niger*, *Lepomis cyanellus*, and *Pylodictis olivaris* are the first documented localities of these species in the area according to Menhinick (1991). However, review of their distributions within the state indicates that these may be inaccurate records (Menhinick 1991). The chain pickerel is predominantly located within the eastern and some central portions of North Carolina. Our record of the chain pickerel from the French Broad River Basin is far removed from its closest localities in the Yadkin-Pee Dee River Basin. However, it has been recorded from the Savannah River Basin just across the state border into South Carolina. It is possible that the species has somehow crossed river basins and now inhabits parts of the French Broad River Basin. It also is possible that this record was field misidentified and is a northern pike or muskellunge (*Esox lucius* and *E. masquinongy*), given their presence in the French Broad River Basin. However, given the body coloration variation and ocular bar, we feel it is likely that this record was at least a pickerel.

The green sunfish is predominantly located within the central portion of the state, with a few records from the western mountain region (mostly lake records). Our 2 records of this species within the Broad River Basin is a significant distance from its documented localities in southeastern Catawba River Basin and the western mountain region. Given the presence of *Chaenobryttus gulosus* (warmouth) in the immediate area, it is possible that these 2 records were misidentified as green sunfish rather than warmouth. However, with the presence of Lake Lure and Lake Adger in the river basin, and the potential of species transfer for fishing purposes, it is possible that these records are accurate.

Unlike the previous 2 species, the flathead catfish has a sporadic distribution throughout North Carolina, making uncertain records more difficult to clarify without the actual specimen(s). Our record of the flathead catfish in the Broad River Basin is even more tenuous since the individual was observed while snorkeling. Given the specimen's size, shape, and coloration, it was identified as a flathead catfish. Questionable stream records just across the Polk County line into the French Broad River Basin lend some credence that this record may be accurate. Given this species voracious appetite and potential to decimate nongame species in the vicinity, it is important that this exotic's existence within the Green River and surrounding area be documented.

While no threatened or endangered fish species was collected during the survey of Green River Game Land, continual research and status surveys are needed to determine the present status of each species. Current land management practices, including agriculture and urbanization, are having an effect on the fish fauna in North Carolina. As nongame biologists, we need to identify which species are at risk and identify ways to reduce or eliminate the impacts.

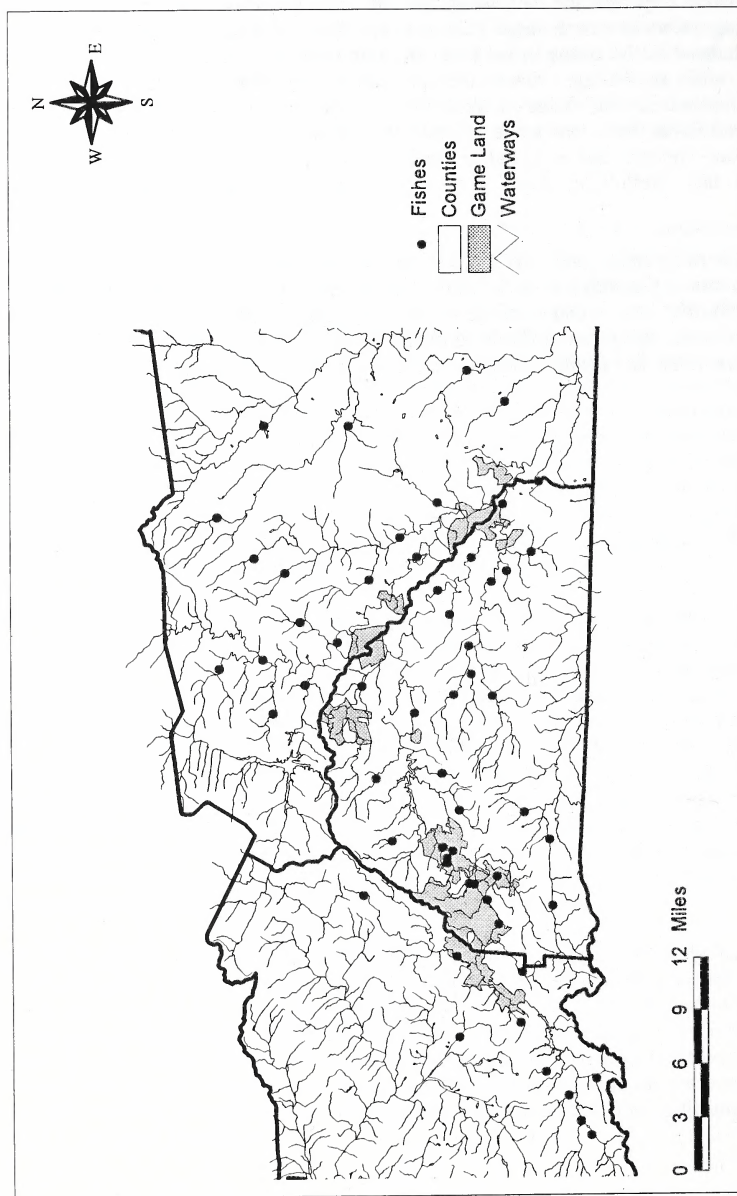


Figure 5. Map of sites indicating where freshwater fishes were collected in the Green River Game Land aquatic inventory, Henderson, Polk, and Rutherford counties, North Carolina, 1999.

Table 5a. Freshwater fish species found in Green River Game Land and associated waterways.

Catostomidae

<i>Catostomus commersoni</i>	white sucker
<i>Hypentelium nigricans</i>	northern hog sucker
<i>Moxostoma collapsum</i>	v-lip redbhorse
<i>Scartomyzon rupiscartes</i>	striped jumprock
<i>Scartomyzon</i> sp.	brassy jumprock

Centrarchidae

<i>Chaenobryttus gulosus</i>	warmouth
<i>Lepomis auritus</i>	redbreast sunfish
<i>Lepomis cyanellus</i>	green sunfish
<i>Lepomis gibbosus</i>	pumpkinseed
<i>Lepomis macrochirus</i>	bluegill
<i>Micropterus salmoides</i>	largemouth bass

Cottidae

<i>Cottus bairdi</i>	mottled sculpin
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Cyprinidae

<i>Campostoma anomalum</i>	central stoneroller
<i>Clinostomus funduloides</i>	rosyside dace
<i>Cyprinella chloristia</i>	greenfin shiner
<i>Cyprinella labrosa</i>	thicklip shiner
<i>Cyprinella pyrrhomelas</i>	fieryblack shiner
<i>Cyprinella nivea</i>	whitefin shiner
<i>Cyprinella zanema</i>	Santee shiner
<i>Hybopsis hypsinotus</i>	highback chub
<i>Luxilus coccogenis</i>	warpaint shiner
<i>Nocomis leptcephalus</i>	bluehead chub
<i>Nocomis micropogon</i>	river chub
<i>Notropis hudsonius</i>	spottail shiner
<i>Notropis lutipinnis</i>	yellowfin shiner
<i>Notropis rubricroceus</i>	saffron shiner
<i>Notropis scepticus</i>	sandbar shiner
<i>Notropis spectrunculus</i>	mirror shiner
<i>Rhinichthys atratulus</i>	blacknose dace
<i>Semotilus atromaculatus</i>	creek chub

Esocidae

<i>Esox niger</i>	chain pickerel
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Table 5a (cont.). Freshwater fish species found in Green River Game Land and associated waterways.

Ictaluridae	
<i>Ameiurus brunneus</i>	snail bullhead
<i>Ameiurus platycephalus</i>	flat bullhead
<i>Noturus insignis</i>	marginated madtom
<i>Pylodictis olivaris</i>	flathead catfish
Percichthyidae	
<i>Morone chrysops</i>	white bass
Percidae	
<i>Etheostoma flabellare</i>	fantail darter
<i>Etheostoma olmstedii</i>	tesselated darter
<i>Etheostoma thalassinum</i>	seagreen darter
<i>Percina crassa</i>	piedmont darter
Salmonidae	
<i>Oncorhynchus mykiss</i>	rainbow trout
<i>Salvelinus fontinalis</i>	brook trout

Table 5b. Freshwater fish species found in Green River Game Land and associated waterways.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Ameiurus brunneus</i>							
990831.1btw	8/31/1999	Broad	Polk	White Oak Creek	SR 1005-	rare	B.T. Watson, W.C. Starnes
990923.2btw	9/23/1999	Broad	Polk	Green River	SR 1331-/+	uncommon	B.T. Watson, W.C. Starnes
990923.3btw	9/23/1999	Broad	Polk	Green River	SR 1302+	rare	B.T. Watson
<i>Ameiurus platycephalus</i>							
990831.4btw	8/31/1999	Broad	Rutherford	Cleghorn Creek	SR 1149-	rare	B.T. Watson
990901.1btw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
990922.3btw	9/22/1999	Broad	Rutherford	Broad River	US 64-74A @ SR 1184-	abundant	B.T. Watson
990923.1btw	9/23/1999	Broad	Rutherford	Broad River	SR 1155-	rare	B.T. Watson
990923.4btw	9/23/1999	Broad	Polk	Green River	SR 1313+	uncommon	B.T. Watson
991026.1btw	10/26/1999	Broad	Polk	Machine Creek	SR 1330-	rare	B.T. Watson
991027.5btw	10/27/1999	Broad	Rutherford	Broad River	SR 1181+	rare	B.T. Watson
<i>Ameiurus sp.</i>							
990902.1btw	9/2/1999	Broad	Polk	Green River	SR 1005 -/+	present	B.T. Watson
990902.2btw	9/2/1999	Broad	Polk	Broad River	SR 1155-/+	present	B.T. Watson
<i>Campostoma anomalum</i>							
990811.1btw	8/11/1999	Broad	Polk	Green River	SR 1151-	common	B.T. Watson
990811.2btw	8/11/1999	Broad	Polk	Green River	SR 1151-/+	rare	B.T. Watson
990811.3btw	8/11/1999	Broad	Polk	Cove Creek	SR 1151-/+	abundant	B.T. Watson
990812.1btw	8/12/1999	Broad	Polk	Green River	SR 1151-	common	B.T. Watson
990915.1btw	9/15/1999	French Broad	Henderson	Bat Fork Creek	SR 1783-/+	present	B.T. Watson
990921.1btw	9/21/1999	Broad	Henderson	Green River	SR 1104+	present	B.T. Watson
990921.2btw	9/21/1999	Broad	Henderson	Rock Creek	SR 1106-	present	B.T. Watson
990922.6btw	9/22/1999	Broad	Henderson	Big Hungry River	SR 1802-/+	present	B.T. Watson
991011.5btw	10/11/1999	Broad	Rutherford	Cove Creek	SR 1337-	present	B.T. Watson, W.C. Starnes
991012.1btw	10/12/1999	French Broad	Henderson	Bat Fork Creek	SR 1783-/+	abundant	B.T. Watson
991012.2btw	10/12/1999	Broad	Henderson	Green River	SR 1104+	uncommon	B.T. Watson
991012.3btw	10/12/1999	Broad	Henderson	Rock Creek	SR 1106-	common	B.T. Watson
991012.4btw	10/12/1999	Broad	Henderson	Joe Creek	SR 1106-	uncommon	B.T. Watson
991027.1btw	10/27/1999	Broad	Henderson	Big Hungry River	SR 1802-/+	common	B.T. Watson
991027.5btw	10/27/1999	Broad	Rutherford	Broad River	SR 1181+	rare	B.T. Watson

Table 5b (cont.). Freshwater fish species found in Green River Game Land and associated waterways.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Catostomus commersoni</i>							
990811.1bw	8/11/1999	Broad	Polk	Green River	SR 1151-	rare	B.T. Watson
990831.4bw	8/31/1999	Broad	Rutherford	Cleghorn Creek	SR 1149-	rare	B.T. Watson
990831.5bw	8/31/1999	Broad	Polk	Mill Creek	SR 1339-	rare	B.T. Watson
991011.5bw	10/11/1999	Broad	Rutherford	Cove Creek	SR 1337-	rare	B.T. Watson
991012.4bw	10/12/1999	Broad	Henderson	Joe Creek	SR 1106-	rare	B.T. Watson
991012.5bw	10/12/1999	Broad	Polk	North Paoclet River	US 176 @ SR 1125-/+	rare	B.T. Watson, W.C. Starnes
991026.1bw	10/26/1999	Broad	Rutherford	Floyd's Creek	SR 2152+	rare	B.T. Watson
991026.2bw	10/26/1999	Broad	Rutherford	Richardson Creek	SR 1135-	rare	B.T. Watson
991026.3bw	10/26/1999	Broad	Polk	Machine Creek	SR 1330-	rare	B.T. Watson
991027.1bw	10/27/1999	Broad	Henderson	Big Hungry River	SR 1802-/+	rare	B.T. Watson
<i>Chaenobryttus gulosus</i>							
990811.1bw	8/11/1999	Broad	Polk	Green River	SR 1151-	rare	B.T. Watson
<i>Clinostomus funduloides</i>							
990811.1bw	8/11/1999	Broad	Polk	Green River	SR 1151-	common	B.T. Watson
990811.2bw	8/11/1999	Broad	Polk	Green River	SR 1151-/+	common	B.T. Watson
990812.3bw	8/12/1999	Broad	Polk	Cove Creek	SR 1151-	uncommon	B.T. Watson
990813.1bw	8/13/1999	Broad	Polk	Gadd Creek	SR 1142+	present	B.T. Watson
990813.2bw	8/13/1999	Broad	Polk	Cove Creek	SR 1142+	present	B.T. Watson
990813.3bw	8/13/1999	Broad	Polk	Ostin Creek	SR 1142-/+	present	B.T. Watson
990830.2bw	8/30/1999	Broad	Polk	Silver Creek	SR 1138-/+	present	B.T. Watson
990831.2bw	8/31/1999	Broad	Polk	Wheat Creek	SR 1329+	present	B.T. Watson
990831.4bw	8/31/1999	Broad	Polk	Green Creek	SR 1340+	common	B.T. Watson
990831.5bw	8/31/1999	Broad	Rutherford	Cleghorn Creek	SR 1149-	rare	B.T. Watson
990908.2bw	9/8/1999	Broad	Polk	Mill Creek	SR 1339-	rare	B.T. Watson
990910.3bw	9/10/1999	Broad	Rutherford	Maple Creek	by SR 1178 -/+	present	B.T. Watson
990914.3bw	9/14/1999	Broad	Rutherford	Cedar Creek	SR 1008+	present	B.T. Watson
990921.2bw	9/21/1999	Broad	Rutherford	Richardson Creek	SR 1135+	present	B.T. Watson
990921.6bw	9/21/1999	Broad	Henderson	Rock Creek	SR 1106-	present	B.T. Watson
990922.2bw	9/22/1999	Broad	Polk	Skyuka Creek	SR 1135-	common	B.T. Watson
991011.1bw	10/11/1999	Broad	Polk	Unnamed tributary to Lake Adger	SR 1156-/+	present	B.T. Watson
991011.2bw	10/11/1999	Broad	Rutherford	Second Broad River	SR 1602-	rare	B.T. Watson
991011.4bw	10/11/1999	Broad	Rutherford	East Branch (Mountain Creek)	SR 1331-	common	B.T. Watson
			Rutherford	Knob Creek	US 64-74A+	rare	B.T. Watson

Table 5b (cont.). Freshwater fish species found in Green River Game Land and associated waterways.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Clinostomus funduloides</i>							
991012.5bw	10/12/1999	Broad	Polk	North Pascolet River	US 176 @ SR 1125-/+	uncommon	B.T. Watson
991026.1bw	10/26/1999	Broad	Rutherford	Floyd's Creek	SR 2152+	rare	B.T. Watson
991027.3bw	10/27/1999	Broad	Polk	Ostin Creek	SR 1142+	abundant	B.T. Watson
<i>Cottus bairdi</i>							
990811.1bw	8/11/1999	Broad	Polk	Green River	SR 1151-	common	B.T. Watson, W.C. Starnes
990811.2bw	8/11/1999	Broad	Polk	Green River	SR 1151-/+	uncommon	B.T. Watson
990811.3bw	8/11/1999	Broad	Polk	Cove Creek	SR 1151-/+	rare	B.T. Watson
990812.3bw	8/12/1999	Broad	Polk	Gadd Creek	SR 1151-	present	B.T. Watson
990915.2bw	9/15/1999	Broad	Henderson	Joe Creek	SR 1106+	present	B.T. Watson
990921.1bw	9/21/1999	Broad	Henderson	Green River	SR 1104+	present	B.T. Watson
990921.2bw	9/21/1999	Broad	Henderson	Rock Creek	SR 1106-	common	B.T. Watson
990921.3bw	9/21/1999	Broad	Henderson	Bob's Creek	SR 1101 @ SR 1104-	present	B.T. Watson
991012.2bw	10/12/1999	Broad	Henderson	Green River	SR 1104+	common	B.T. Watson
991012.3bw	10/12/1999	Broad	Henderson	Rock Creek	SR 1106-	common	B.T. Watson
991012.4bw	10/12/1999	Broad	Henderson	Joe Creek	SR 1106-	rare	B.T. Watson
991027.1bw	10/27/1999	Broad	Henderson	Big Hungry River	SR 1802-/+	common	B.T. Watson
<i>Cyprinella chloristia</i>							
990811.1bw	8/11/1999	Broad	Polk	Green River	SR 1151-	uncommon	B.T. Watson
990811.2bw	8/11/1999	Broad	Polk	Green River	SR 1151-/+	rare	B.T. Watson, W.C. Starnes
990812.1bw	8/12/1999	Broad	Polk	Green River	SR 1151-	uncommon	B.T. Watson
990901.1bw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
990921.4bw	9/22/1999	Broad	Rutherford	Second Broad River	SR 1602-	present	B.T. Watson, W.C. Starnes
991011.5bw	10/11/1999	Broad	Rutherford	Cove Creek	SR 1337-	present	B.T. Watson, W.C. Starnes
991027.5bw	10/27/1999	Broad	Rutherford	Broad River	SR 1181+	rare	B.T. Watson, W.C. Starnes
<i>Cyprinella labrosa</i>							
990811.1bw	8/11/1999	Broad	Polk	Green River	SR 1151-	rare	B.T. Watson, W.C. Starnes
990811.2bw	8/11/1999	Broad	Polk	Green River	SR 1151-/+	common	B.T. Watson, W.C. Starnes
990812.1bw	8/12/1999	Broad	Polk	Green River	SR 1151-	rare	B.T. Watson
990923.3bw	9/23/1999	Broad	Polk	Green River	SR 1302+	rare	B.T. Watson, W.C. Starnes
991011.5bw	10/11/1999	Broad	Rutherford	Cove Creek	SR 1337-	common	B.T. Watson, W.C. Starnes
991027.2bw	10/27/1999	Broad	Polk	Green River	SR 1151-/+	uncommon	B.T. Watson, W.C. Starnes
991027.3bw	10/27/1999	Broad	Rutherford	Broad River	SR 1181+	common	B.T. Watson, W.C. Starnes

Table 5b (cont.). Freshwater fish species found in Green River Game Land and associated waterways.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Cyprinella labrosa/zanema</i>							
990901.1btw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
990901.2btw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
<i>Cyprinella nivea</i>							
990923.1btw	9/23/1999	Broad	Rutherford	Broad River	SR 1155-	rare	B.T. Watson, W.C. Starnes
<i>Cyprinella pyrrhomelas</i>							
990811.1btw	8/11/1999	Broad	Polk	Green River	SR 1151-	abundant	B.T. Watson, W.C. Starnes
990811.2btw	8/11/1999	Broad	Polk	Green River	SR 1151-/+	common	B.T. Watson
990811.3btw	8/11/1999	Broad	Polk	Cove Creek	SR 1151-/+	common	B.T. Watson
990812.1btw	8/12/1999	Broad	Polk	Green River	SR 1151-	common	B.T. Watson
990813.4btw	8/13/1999	Broad	Polk	Green River	SR 1313+	present	B.T. Watson
990831.1btw	8/31/1999	Broad	Polk	White Oak Creek	SR 1005-	rare	B.T. Watson
990831.2btw	8/31/1999	Broad	Polk	Green Creek	SR 1340+	rare	B.T. Watson
990901.1btw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
990901.2btw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
990909.6btw	9/9/1999	Broad	Rutherford	Broad River	SR 1181+	present	B.T. Watson
990921.5btw	9/21/1999	Broad	Polk	North Paolet River	US 176 @ SR 1125-/+	present	B.T. Watson
990921.6btw	9/21/1999	Broad	Polk	Skyuka Creek	SR 1135-	present	B.T. Watson
990923.1btw	9/23/1999	Broad	Rutherford	Broad River	SR 1155-	rare	W.C. Starnes
990923.2btw	9/23/1999	Broad	Polk	Green River	SR 1331-/+	rare	B.T. Watson, W.C. Starnes
990923.3btw	9/23/1999	Broad	Polk	Green River	SR 1302+	rare	B.T. Watson, W.C. Starnes
990923.4btw	9/23/1999	Broad	Polk	Green River	SR 1313+	uncommon	B.T. Watson, W.C. Starnes
991011.5btw	10/11/1999	Broad	Rutherford	Cove Creek	SR 1337-	common	B.T. Watson
991011.6btw	10/11/1999	Broad	Rutherford	Cedar Creek	SR 1008-	common	B.T. Watson
991012.5btw	10/12/1999	Broad	Polk	North Paolet River	US 176 @ SR 1125-/+	uncommon	B.T. Watson
991026.1btw	10/26/1999	Broad	Rutherford	Floyd's Creek	SR 2152+	common	B.T. Watson
991026.3btw	10/26/1999	Broad	Polk	Machine Creek	SR 1330-	uncommon	B.T. Watson
991027.2btw	10/27/1999	Broad	Polk	Green River	SR 1151-/+	uncommon	B.T. Watson
991027.4btw	10/27/1999	Broad	Polk	Walnut Creek	SR 1311-	rare	B.T. Watson
991027.5btw	10/27/1999	Broad	Rutherford	Broad River	SR 1181+	common	B.T. Watson, W.C. Starnes
<i>Cyprinella sp.</i>							
990902.2btw	9/2/1999	Broad	Polk	Broad River	SR 1155-/+	present	B.T. Watson
990909.6btw	9/9/1999	Broad	Rutherford	Broad River	SR 1181+	present	B.T. Watson

Table 5b (cont.). Freshwater fish species found in Green River Game Land and associated waterways.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Cyprinella zanema</i>							
990831.1btw	8/31/1999	Broad	Polk	White Oak Creek	SR 1005-	rare	B.T. Watson, W.C. Starnes
991011.5btw	10/11/1999	Broad	Rutherford	Cove Creek	SR 1337-	present	W.C. Starnes
991026.3btw	10/26/1999	Broad	Polk	Machine Creek	SR 1330-	rare	B.T. Watson
<i>Exocoetis niger</i>							
991012.1btw	10/12/1999	French Broad	Henderson	Bat Fork Creek	SR 1783-/+	rare	B.T. Watson
<i>Etheostoma flabellare</i>							
990811.1btw	8/11/1999	Broad	Polk	Green River	SR 1151-	rare	B.T. Watson
990811.2btw	8/11/1999	Broad	Polk	Green River	SR 1151-/+	common	B.T. Watson
990811.3btw	8/11/1999	Broad	Polk	Cove Creek	SR 1151-/+	common	B.T. Watson
990812.1btw	8/12/1999	Broad	Polk	Green River	SR 1151-	uncommon	B.T. Watson
990831.2btw	8/31/1999	Broad	Polk	Green Creek	SR 1340+	rare	B.T. Watson
990831.5btw	8/31/1999	Broad	Polk	Mill Creek	SR 1339-	rare	B.T. Watson
990901.1btw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
990901.2btw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
990902.1btw	9/2/1999	Broad	Polk	Green River	SR 1005-/+	present	B.T. Watson
990908.1btw	9/8/1999	Broad	Rutherford	Mountain Creek	NC 108-/+	present	B.T. Watson
990909.1btw	9/9/1999	Broad	Polk	White Oak Creek	SR 1326-	present	B.T. Watson
990909.3btw	9/9/1999	Broad	Polk	Little White Oak Creek	SR 1322+	present	B.T. Watson
990910.4btw	9/10/1999	Broad	Rutherford	East Branch Mountain Creek	SR 1331-	present	B.T. Watson
990914.1btw	9/14/1999	Broad	Rutherford	Cathys Creek	SR 1325+	present	B.T. Watson
990914.2btw	9/14/1999	Broad	Rutherford	Holland Creek	SR 1538-	present	B.T. Watson
990922.4btw	9/22/1999	Broad	Rutherford	Second Broad River	SR 1602-	present	B.T. Watson
991011.1btw	10/11/1999	Broad	Rutherford	Second Broad River	SR 1602-	common	B.T. Watson
991011.2btw	10/11/1999	Broad	Rutherford	East Branch Mountain Creek	SR 1331-	uncommon	B.T. Watson
991026.2btw	10/26/1999	Broad	Rutherford	Richardson Creek	SR 1135-	rare	B.T. Watson
991027.2btw	10/27/1999	Broad	Polk	Green River	SR 1151-/+	uncommon	B.T. Watson
991027.3btw	10/27/1999	Broad	Polk	Ostin Creek	SR 1142+	rare	B.T. Watson
<i>Etheostoma olmstedi</i>							
990811.1btw	8/11/1999	Broad	Polk	Green River	SR 1151-	abundant	B.T. Watson
990811.2btw	8/11/1999	Broad	Polk	Green River	SR 1151-/+	uncommon	B.T. Watson
990811.3btw	8/11/1999	Broad	Polk	Cove Creek	SR 1151-/+	uncommon	B.T. Watson
990812.1btw	8/12/1999	Broad	Polk	Green River	SR 1151-	uncommon	B.T. Watson

Table 5b (cont.). Freshwater fish species found in Green River Game Land and associated waterways.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Etheostoma olmstedii</i>							
990813.4btw	8/13/1999	Broad	Polk	Green River	SR 1313+	present	B.T. Watson
990830.1btw	8/30/1999	Broad	Polk	Green River	SR 1331+	present	B.T. Watson
990831.1btw	8/31/1999	Broad	Polk	White Oak Creek	SR 1005-	rare	B.T. Watson
990831.2btw	8/31/1999	Broad	Polk	Green Creek	SR 1340+	rare	B.T. Watson
990831.3btw	8/31/1999	Broad	Polk	Green River	SR 1302+	present	B.T. Watson
990831.4btw	8/31/1999	Broad	Rutherford	Cleghorn Creek	SR 1149-	rare	B.T. Watson
990831.5btw	8/31/1999	Broad	Polk	Mill Creek	SR 1339-	common	B.T. Watson
990901.1btw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
990901.2btw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
990902.2btw	9/2/1999	Broad	Polk	Broad River	SR 1155-/+	present	B.T. Watson
990908.1btw	9/8/1999	Broad	Rutherford	Mountain Creek	NC 108-/+	present	B.T. Watson
990909.2btw	9/9/1999	Broad	Polk	South Branch	NC 9-	present	B.T. Watson
990909.3btw	9/9/1999	Broad	Polk	Walnut Creek	SR 1311-	present	B.T. Watson
990909.6btw	9/9/1999	Broad	Rutherford	Broad River	SR 1181+	present	B.T. Watson
990910.2btw	9/10/1999	Broad	Rutherford	Cove Creek	SR 1337-	present	B.T. Watson
990910.3btw	9/10/1999	Broad	Rutherford	Cedar Creek	SR 1008+	present	B.T. Watson
990914.3btw	9/14/1999	Broad	Rutherford	Richardson Creek	SR 1135+	present	B.T. Watson
990920.1btw	9/20/1999	Broad	Rutherford	Floyd's Creek	SR 2152-	present	B.T. Watson
990923.1btw	9/23/1999	Broad	Rutherford	Broad River	SR 1155-	rare	B.T. Watson
990923.2btw	9/23/1999	Broad	Polk	Green River	SR 1331-/+	rare	B.T. Watson
990923.3btw	9/23/1999	Broad	Polk	Green River	SR 1302+	rare	B.T. Watson
990923.4btw	9/23/1999	Broad	Polk	Green River	SR 1337-	rare	B.T. Watson
991011.5btw	10/11/1999	Broad	Rutherford	Cove Creek	SR 1337+	uncommon	B.T. Watson
991026.1btw	10/26/1999	Broad	Rutherford	Floyd's Creek	SR 2152+	uncommon	B.T. Watson
991026.2btw	10/26/1999	Broad	Rutherford	Richardson Creek	SR 1135-	common	B.T. Watson
991026.4btw	10/26/1999	Broad	Polk	White Oak Creek	SR 1526-	uncommon	B.T. Watson
991027.2btw	10/27/1999	Broad	Polk	Green River	SR 1151-/+	rare	B.T. Watson
991027.4btw	10/27/1999	Broad	Polk	Walnut Creek	SR 1311-	rare	B.T. Watson
991027.5btw	10/27/1999	Broad	Rutherford	Broad River	SR 1181+	uncommon	B.T. Watson
<i>Etheostoma thalassinum</i>							
990811.1btw	8/11/1999	Broad	Polk	Green River	SR 1151-	abundant	B.T. Watson, W.C. Starnes
990811.2btw	8/11/1999	Broad	Polk	Green River	SR 1151-/+	common	B.T. Watson
990811.3btw	8/11/1999	Broad	Polk	Cove Creek	SR 1151-/+	common	B.T. Watson
990812.1btw	8/12/1999	Broad	Polk	Green River	SR 1151-	common	B.T. Watson

Table 5b (cont.). Freshwater fish species found in Green River Game Land and associated waterways.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Etheostoma thalassinum</i>							
990813.4btw	8/13/1999	Broad	Polk	Green River	SR 1313+	common	B.T. Watson
990830.1btw	8/30/1999	Broad	Polk	Green River	SR 1331+	present	B.T. Watson
990831.1btw	8/31/1999	Broad	Polk	Green Creek	SR 1340+	rare	B.T. Watson
990831.4btw	8/31/1999	Broad	Rutherford	Cleghorn Creek	SR 1149-	rare	B.T. Watson
990831.5btw	8/31/1999	Broad	Polk	Mill Creek	SR 1339-	uncommon	B.T. Watson
990901.1btw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
990901.2btw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
990902.1btw	9/2/1999	Broad	Polk	Green River	SR 1005 -/+	present	B.T. Watson
990908.1btw	9/8/1999	Broad	Rutherford	Mountain Creek	NC 108-/+	present	B.T. Watson
990908.4btw	9/8/1999	Broad	Rutherford	West Branch (Mountain Creek)	SR 1351+	present	B.T. Watson
990909.6btw	9/9/1999	Broad	Rutherford	Broad River	SR 1181+	present	B.T. Watson
990910.3btw	9/10/1999	Broad	Rutherford	Cedar Creek	SR 1008+	present	B.T. Watson
990921.5btw	9/21/1999	Broad	Polk	North Pacolet River	US 176 @ SR 1125-/+	present	B.T. Watson
990921.6btw	9/21/1999	Broad	Polk	Skyuka Creek	SR 1135-	present	B.T. Watson
990922.3btw	9/22/1999	Broad	Rutherford	Broad River	US 64-74A @ SR 1184-	common	B.T. Watson
990923.1btw	9/23/1999	Broad	Rutherford	Broad River	SR 1155-	rare	B.T. Watson
990923.2btw	9/23/1999	Broad	Polk	Green River	SR 1331 -/+	uncommon	B.T. Watson
990923.3btw	9/23/1999	Broad	Polk	Green River	SR 1302+	common	B.T. Watson
990923.4btw	9/23/1999	Broad	Polk	Green River	SR 1313+	common	B.T. Watson
991011.5btw	10/11/1999	Broad	Rutherford	Cove Creek	SR 1337-	rare	B.T. Watson
991011.6btw	10/11/1999	Broad	Rutherford	Cedar Creek	SR 1008-	common	B.T. Watson
991012.5btw	10/12/1999	Broad	Polk	North Pacolet River	US 176 @ SR 1125-/+	rare	B.T. Watson
991026.1btw	10/26/1999	Broad	Rutherford	Floyd's Creek	SR 2152+	rare	B.T. Watson
991026.2btw	10/26/1999	Broad	Rutherford	Richardson Creek	SR 1135-	rare	B.T. Watson
991027.2btw	10/27/1999	Broad	Polk	Green River	SR 1151 -/+	abundant	B.T. Watson
991027.3btw	10/27/1999	Broad	Polk	Ostin Creek	SR 1142+	rare	B.T. Watson, W.C. Starnes
991027.5btw	10/27/1999	Broad	Rutherford	Broad River	SR 1181+	rare	B.T. Watson
<i>Hypopsis hypsinotus</i>							
990914.1btw	9/14/1999	Broad	Rutherford	Cathays Creek	SR 1325+	present	B.T. Watson
990914.3btw	9/14/1999	Broad	Rutherford	Richardson Creek	SR 1135+	present	B.T. Watson
990921.6btw	9/21/1999	Broad	Polk	Skyuka Creek	SR 1135-	present	B.T. Watson, W.C. Starnes
991012.5btw	10/12/1999	Broad	Polk	North Pacolet River	US 176 @ SR 1125-/+	rare	B.T. Watson, W.C. Starnes

Table 5b (cont.). Freshwater fish species found in Green River Game Land and associated waterways.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Hypentelium nigricans</i>							
990811.1bw	8/11/1999	Broad	Polk	Green River	SR 1151-	uncommon	B.T. Watson
990811.2bw	8/11/1999	Broad	Polk	Green River	SR 1151-/+	uncommon	B.T. Watson
990811.3bw	8/11/1999	Broad	Polk	Cove Creek	SR 1151-/+	common	B.T. Watson, W.C. Starnes
990830.1bw	8/30/1999	Broad	Polk	Green River	SR 1331+	present	B.T. Watson
990831.1bw	8/31/1999	Broad	Polk	White Oak Creek	SR 1005-	uncommon	B.T. Watson
990831.2bw	8/31/1999	Broad	Polk	Green Creek	SR 1340+	rare	B.T. Watson
990831.3bw	8/31/1999	Broad	Polk	Green River	SR 1302+	present	B.T. Watson
990831.5bw	8/31/1999	Broad	Polk	Mill Creek	SR 1339-	uncommon	B.T. Watson
990901.1bw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
990901.2bw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
990909.6bw	9/9/1999	Broad	Rutherford	Broad River	SR 1181+	present	B.T. Watson
990914.3bw	9/14/1999	Broad	Rutherford	Richardson Creek	SR 1135+	present	B.T. Watson
990915.1bw	9/15/1999	French Broad	Henderson	Bat Fork Creek	SR 1783-/+	present	B.T. Watson
990921.1bw	9/21/1999	Broad	Henderson	Green River	SR 1104+	present	B.T. Watson
990921.2bw	9/21/1999	Broad	Henderson	Rock Creek	SR 1106-	present	B.T. Watson
990921.4bw	9/21/1999	Broad	Polk	North Pacolet River	US 176-	present	B.T. Watson
990923.3bw	9/23/1999	Broad	Polk	Green River	SR 1302+	rare	B.T. Watson
990923.4bw	9/23/1999	Broad	Polk	Green River	SR 1313+	uncommon	B.T. Watson
991011.5bw	10/11/1999	Broad	Rutherford	Cove Creek	SR 1337-	rare	B.T. Watson
991012.1bw	10/12/1999	French Broad	Henderson	Bat Fork Creek	SR 1783-/+	common	B.T. Watson
991012.3bw	10/12/1999	Broad	Henderson	Rock Creek	SR 1106-	common	B.T. Watson
991012.4bw	10/12/1999	Broad	Henderson	Joe Creek	SR 1106-	rare	B.T. Watson
991026.1bw	10/26/1999	Broad	Rutherford	Floyd's Creek	SR 2152+	uncommon	B.T. Watson
991026.2bw	10/26/1999	Broad	Rutherford	Richardson Creek	SR 1135-	rare	B.T. Watson
991026.4bw	10/26/1999	Broad	Polk	White Oak Creek	SR 1526-	rare	B.T. Watson
991027.2bw	10/27/1999	Broad	Polk	Green River	SR 1151-/+	rare	B.T. Watson
<i>Lepomis auritus</i>							
990811.1bw	8/11/1999	Broad	Polk	Green River	SR 1151-	uncommon	B.T. Watson
990811.2bw	8/11/1999	Broad	Polk	Green River	SR 1151-/+	rare	B.T. Watson
990811.3bw	8/11/1999	Broad	Polk	Cove Creek	SR 1151-/+	rare	B.T. Watson
990812.1bw	8/12/1999	Broad	Polk	Green River	SR 1151-	common	B.T. Watson
990813.4bw	8/13/1999	Broad	Polk	Green River	SR 1313+	present	B.T. Watson
990831.1bw	8/31/1999	Broad	Polk	White Oak Creek	SR 1005-	rare	B.T. Watson

Table 5b (cont.). Freshwater fish species found in Green River Game Land and associated waterways.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Lepomis aeneus</i>							
990831.4btw	8/31/1999	Broad	Rutherford	Cleghorn Creek	SR 1149-	uncommon	B.T. Watson
990831.5btw	8/31/1999	Broad	Polk	Mill Creek	SR 1339-	rare	B.T. Watson
990901.1btw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
990901.2btw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
990902.1btw	9/2/1999	Broad	Polk	Green River	SR 1005 +/-	present	B.T. Watson
990902.2btw	9/2/1999	Broad	Polk	Broad River	SR 1155 +/-	present	B.T. Watson
990908.3btw	9/8/1999	Broad	Rutherford	Knob Creek	US 64-74A+	present	B.T. Watson
990909.1btw	9/9/1999	Broad	Polk	White Oak Creek	SR 1526-	present	B.T. Watson
990909.2btw	9/9/1999	Broad	Polk	South Branch	NC 9-	present	B.T. Watson
990909.4btw	9/9/1999	Broad	Polk	Machine Creek	SR 1330-	present	B.T. Watson
990909.6btw	9/9/1999	Broad	Rutherford	Broad River	SR 1181+	present	B.T. Watson
990910.1btw	9/10/1999	Broad	Rutherford	Bills Creek	SR 1008 +/-	present	B.T. Watson
990914.1btw	9/14/1999	Broad	Rutherford	Cathys Creek	SR 1325+	present	B.T. Watson
990915.1btw	9/15/1999	French Broad	Henderson	Bat Fork Creek	SR 1783 +/-	present	B.T. Watson
990920.1btw	9/20/1999	Broad	Rutherford	Floyd's Creek	SR 2152-	present	B.T. Watson
990922.1btw	9/22/1999	Broad	Polk	Britten Creek	SR 1158 +/-	present	B.T. Watson
990922.3btw	9/22/1999	Broad	Rutherford	Broad River	US 64-74A @ SR 1184-	common	B.T. Watson
990923.1btw	9/23/1999	Broad	Rutherford	Broad River	SR 1155-	common	B.T. Watson
990923.2btw	9/23/1999	Broad	Polk	Green River	SR 1331 +/-	common	B.T. Watson
990923.3btw	9/23/1999	Broad	Polk	Green River	SR 1302+	rare	B.T. Watson
990923.4btw	9/23/1999	Broad	Polk	Green River	SR 1313+	common	B.T. Watson
991011.1btw	10/11/1999	Broad	Rutherford	Second Broad River	SR 1602-	uncommon	B.T. Watson
991011.3btw	10/11/1999	Broad	Rutherford	West Branch (Mountain Creek)	SR 1351+	rare	B.T. Watson
991011.5btw	10/11/1999	Broad	Rutherford	Cove Creek	SR 1337-	common	B.T. Watson
991011.6btw	10/11/1999	Broad	Rutherford	Cedar Creek	SR 1008-	uncommon	B.T. Watson
991012.1btw	10/12/1999	French Broad	Henderson	Bat Fork Creek	SR 1783 +/-	common	B.T. Watson
991012.3btw	10/12/1999	Broad	Henderson	Rock Creek	SR 1106-	rare	B.T. Watson
991026.3btw	10/26/1999	Broad	Polk	Machine Creek	SR 1330-	uncommon	B.T. Watson
991026.4btw	10/26/1999	Broad	Polk	White Oak Creek	SR 1526-	rare	B.T. Watson
991027.5btw	10/27/1999	Broad	Rutherford	Broad River	SR 1181+	uncommon	B.T. Watson
<i>Lepomis cyanellus</i>							
990811.2btw	8/11/1999	Broad	Polk	Green River	SR 1151 +/-	present	B.T. Watson
991011.3btw	10/11/1999	Broad	Rutherford	West Branch (Mountain Creek)	SR 1351+	rare	B.T. Watson

Table 5b (cont.). Freshwater fish species found in Green River Game Land and associated waterways.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Lepomis gibbosus</i>							
991011.3btw	10/11/1999	Broad	Rutherford	West Branch (Mountain Creek)	SR 1351+	rare	B.T. Watson
<i>Lepomis macrochirus</i>							
990811.1btw	8/11/1999	Broad	Polk	Green River	SR 1151-	common	B.T. Watson
990811.2btw	8/11/1999	Broad	Polk	Green River	SR 1151-/+	uncommon	B.T. Watson
990811.3btw	8/11/1999	Broad	Polk	Cove Creek	SR 1151-/+	rare	B.T. Watson
990812.1btw	8/12/1999	Broad	Polk	Green River	SR 1151-	uncommon	B.T. Watson
990901.2btw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
990923.4btw	9/23/1999	Broad	Polk	Green River	SR 1313+	rare	B.T. Watson
991012.1btw	10/12/1999	French Broad	Henderson	Bat Fork Creek	SR 1783-/+	rare	B.T. Watson
991012.2btw	10/12/1999	Broad	Henderson	Green River	SR 1104+	rare	B.T. Watson
991012.4btw	10/12/1999	Broad	Henderson	Joe Creek	SR 1106-	rare	B.T. Watson
991012.5btw	10/12/1999	Broad	Polk	North Pacolet River	US 176 @ SR 1125-/+	rare	B.T. Watson
<i>Lepomis</i> sp.							
990813.1btw	8/13/1999	Broad	Polk	Cove Creek	SR 1142+	present	B.T. Watson
990914.2btw	9/14/1999	Broad	Rutherford	Holland Creek	SR 1538-	present	B.T. Watson
<i>Luxilus coccogenis</i>							
990921.2btw	9/21/1999	Broad	Henderson	Rock Creek	SR 1106-	present	B.T. Watson
991012.3btw	10/12/1999	Broad	Henderson	Rock Creek	SR 1106-	uncommon	B.T. Watson
991012.4btw	10/12/1999	Broad	Henderson	Joe Creek	SR 1106-	uncommon	B.T. Watson
<i>Micropterus salmoides</i>							
990812.1btw	8/12/1999	Broad	Polk	Green River	SR 1151-	rare	B.T. Watson
990813.4btw	8/13/1999	Broad	Polk	Green River	SR 1313+	present	B.T. Watson
990831.5btw	8/31/1999	Broad	Polk	Mill Creek	SR 1339-	rare	B.T. Watson
990909.6btw	9/9/1999	Broad	Rutherford	Broad River	SR 1181+	present	B.T. Watson
990914.1btw	9/14/1999	Broad	Rutherford	Cathays Creek	SR 1325+	present	B.T. Watson
990914.2btw	9/14/1999	Broad	Rutherford	Holland Creek	SR 1538-	present	B.T. Watson
990923.3btw	9/23/1999	Broad	Polk	Green River	SR 1302+	rare	B.T. Watson
991011.2btw	10/11/1999	Broad	Rutherford	East Branch (Mountain Creek)	SR 1331-	rare	B.T. Watson
991012.1btw	10/12/1999	French Broad	Henderson	Bat Fork Creek	SR 1783-/+	rare	B.T. Watson
991026.3btw	10/26/1999	Broad	Polk	Machine Creek	SR 1330-	rare	B.T. Watson

Table 5b (cont.). Freshwater fish species found in Green River Game Land and associated waterways.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Morone chrysops</i>							
990901.3btw	9/1/1999	Broad	Polk	Green River	SR 1151+	present (visual)	B.T. Watson
<i>Moxostoma collapsus</i>							
990811.1btw	8/11/1999	Broad	Polk	Green River	SR 1151-	rare	B.T. Watson
990811.2btw	8/11/1999	Broad	Polk	Green River	SR 1151-/+	common	B.T. Watson, W.C. Starnes
990923.1btw	9/23/1999	Broad	Rutherford	Broad River	SR 1155-	rare	B.T. Watson, W.C. Starnes
<i>Moxostoma sp./Scartomyzon sp.</i>							
990811.3btw	8/11/1999	Broad	Polk	Cove Creek	SR 1151-/+	rare	B.T. Watson
990813.4btw	8/13/1999	Broad	Polk	Green River	SR 1313+	present	B.T. Watson
990901.2btw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
990914.2btw	9/14/1999	Broad	Rutherford	Holland Creek	SR 1538-	present	B.T. Watson
<i>Nocomis leptocephalus</i>							
990811.1btw	8/11/1999	Broad	Polk	Green River	SR 1151-	common	B.T. Watson
990811.2btw	8/11/1999	Broad	Polk	Green River	SR 1151-/+	common	B.T. Watson
990811.3btw	8/11/1999	Broad	Polk	Cove Creek	SR 1151-/+	abundant	B.T. Watson
990812.1btw	8/12/1999	Broad	Polk	Green River	SR 1151-	common	B.T. Watson
990812.3btw	8/12/1999	Broad	Polk	Gadd Creek	SR 1151-	patchy rare	B.T. Watson
990813.1btw	8/13/1999	Broad	Polk	Cove Creek	SR 1142+	present	B.T. Watson
990813.2btw	8/13/1999	Broad	Polk	Ostin Creek	SR 1142-/+	present	B.T. Watson
990813.4btw	8/13/1999	Broad	Polk	Green River	SR 1313+	present	B.T. Watson
990830.2btw	8/30/1999	Broad	Polk	Wheat Creek	SR 1329+	present	B.T. Watson
990831.1btw	8/31/1999	Broad	Polk	White Oak Creek	SR 1005-	common	B.T. Watson
990831.2btw	8/31/1999	Broad	Polk	Green Creek	SR 1340+	common	B.T. Watson
990831.3btw	8/31/1999	Broad	Polk	Green River	SR 1302+	present	B.T. Watson
990831.4btw	8/31/1999	Broad	Rutherford	Cleghorn Creek	SR 1149-	common	B.T. Watson
990831.5btw	8/31/1999	Broad	Polk	Mill Creek	SR 1339-	common	B.T. Watson
990901.1btw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
990901.2btw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
990908.1btw	9/8/1999	Broad	Rutherford	Mountain Creek	NC 108-/+	present	B.T. Watson
990908.2btw	9/8/1999	Broad	Rutherford	Maple Creek	by SR 1178 -/+	present	B.T. Watson
990908.3btw	9/8/1999	Broad	Rutherford	Knob Creek	US 64-74A+	present	B.T. Watson
990908.4btw	9/8/1999	Broad	Rutherford	West Branch (Mountain Creek)	SR 1351+	present	B.T. Watson
990909.1btw	9/9/1999	Broad	Polk	White Oak Creek	SR 1526-	present	B.T. Watson

Table 5b (cont.). Freshwater fish species found in Green River Game Land and associated waterways.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Nocomis leptocephalus</i>							
990909.2btw	9/9/1999	Broad	Polk	South Branch	NC 9-	present	B.T. Watson
990909.3btw	9/9/1999	Broad	Polk	Little White Oak Creek	SR 1322+	present	B.T. Watson
990909.4btw	9/9/1999	Broad	Polk	Machine Creek	SR 1330-	present	B.T. Watson
990909.5btw	9/9/1999	Broad	Polk	Walnut Creek	SR 1311-	present	B.T. Watson
990909.6btw	9/9/1999	Broad	Rutherford	Broad River	SR 1181+	present	B.T. Watson
990910.2btw	9/10/1999	Broad	Rutherford	Cove Creek	SR 1337-	present	B.T. Watson
990910.3btw	9/10/1999	Broad	Rutherford	Cedar Creek	SR 1008+	present	B.T. Watson
990914.1btw	9/14/1999	Broad	Rutherford	Cathys Creek	SR 1325+	common	B.T. Watson
990914.2btw	9/14/1999	Broad	Rutherford	Holland Creek	SR 1538-	present	B.T. Watson
990914.3btw	9/14/1999	Broad	Rutherford	Richardson Creek	SR 1135+	present	B.T. Watson
990914.4btw	9/14/1999	Broad	Rutherford/Polk	Henson Creek	SR 1300-	present	B.T. Watson
990915.2btw	9/15/1999	Broad	Henderson	Joe Creek	SR 1106+	present	B.T. Watson
990920.1btw	9/20/1999	Broad	Rutherford	Floyds Creek	SR 2152-	present	B.T. Watson
990921.1btw	9/21/1999	Broad	Henderson	Green River	SR 1104+	present	B.T. Watson
990921.2btw	9/21/1999	Broad	Henderson	Rock Creek	SR 1106-	present	B.T. Watson
990921.3btw	9/21/1999	Broad	Henderson	Bob's Creek	SR 1101 @ SR 1104-	uncommon	B.T. Watson
990921.4btw	9/21/1999	Broad	Polk	North Pacolet River	US 176-	present	B.T. Watson
990921.5btw	9/21/1999	Broad	Polk	North Pacolet River	US 176 @ SR 1125-/+	present	B.T. Watson
990921.6btw	9/21/1999	Broad	Polk	Skyuka Creek	SR 1135-	common	B.T. Watson
990922.1btw	9/22/1999	Broad	Polk	Britten Creek	SR 1158-/+	present	B.T. Watson
990922.2btw	9/22/1999	Broad	Polk	Unnamed tributary to Lake Adger	SR 1156-/+	present	B.T. Watson
990922.4btw	9/22/1999	Broad	Rutherford	Second Broad River	SR 1602-	present	B.T. Watson
990923.1btw	9/23/1999	Broad	Polk	Broad River	SR 1155-	rare	B.T. Watson
990923.2btw	9/23/1999	Broad	Polk	Green River	SR 1331-/+	rare	B.T. Watson
990923.3btw	9/23/1999	Broad	Polk	Green River	SR 1302+	common	B.T. Watson
991011.1btw	10/11/1999	Broad	Rutherford	Second Broad River	SR 1602-	common	B.T. Watson
991011.2btw	10/11/1999	Broad	Rutherford	East Branch (Mountain Creek)	SR 1331-	common	B.T. Watson
991011.3btw	10/11/1999	Broad	Rutherford	West Branch (Mountain Creek)	SR 1351+	common	B.T. Watson
991011.4btw	10/11/1999	Broad	Rutherford	Knob Creek	US 64-74A	common	B.T. Watson
991011.5btw	10/11/1999	Broad	Rutherford	Cove Creek	SR 1337-	common	B.T. Watson
991011.6btw	10/11/1999	Broad	Rutherford	Cedar Creek	SR 1008-	common	B.T. Watson
991012.2btw	10/12/1999	Broad	Henderson	Green River	SR 1104+	common	B.T. Watson
991012.3btw	10/12/1999	Broad	Henderson	Rock Creek	SR 1106-	common	B.T. Watson
991012.4btw	10/12/1999	Broad	Henderson	Joe Creek	SR 1106-	common	B.T. Watson
991012.5btw	10/12/1999	Broad	Polk	North Pacolet River	US 176 @ SR 1125-/+	common	B.T. Watson

Table 5b (cont.). Freshwater fish species found in Green River Game Land and associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>River Basin</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<i><u>Nocomis leptocephalus</u></i>							
991026.1btw	10/26/1999	Broad	Rutherford	Floyd's Creek	SR 2152+	common	B.T. Watson
991026.2btw	10/26/1999	Broad	Rutherford	Richardson Creek	SR 1135-	common	B.T. Watson
991026.3btw	10/26/1999	Broad	Polk	Machine Creek	SR 1330-	common	B.T. Watson
991026.4btw	10/26/1999	Broad	Polk	White Oak Creek	SR 1526-	common	B.T. Watson
991027.2btw	10/27/1999	Broad	Polk	Green River	SR 1151+/-	common	B.T. Watson
991027.3btw	10/27/1999	Broad	Polk	Ostin Creek	SR 1142+	common	B.T. Watson
991027.4btw	10/27/1999	Broad	Polk	Walnut Creek	SR 1311-	common	B.T. Watson
991027.5btw	10/27/1999	Broad	Rutherford	Broad River	SR 1181+	uncommon	B.T. Watson
<i><u>Nocomis micropogon</u></i>							
990915.1btw	9/15/1999	French Broad	Henderson	Bat Fork Creek	SR 1783+/-	present	B.T. Watson
991012.1btw	10/12/1999	French Broad	Henderson	Bat Fork Creek	SR 1783+/-	abundant	B.T. Watson
<i><u>Notropis hudsonius</u></i>							
990811.2btw	8/11/1999	Broad	Polk	Green River	SR 1151+/-	present	B.T. Watson
990909.1btw	9/9/1999	Broad	Polk	White Oak Creek	SR 1526-	present	B.T. Watson, W.C. Starnes
990922.3btw	9/22/1999	Broad	Rutherford	Broad River	US 64-74A @ SR1184-	common	B.T. Watson, W.C. Starnes
990923.1btw	9/23/1999	Broad	Rutherford	Broad River	SR 1155-	common	B.T. Watson, W.C. Starnes
990923.3btw	9/23/1999	Broad	Polk	Green River	SR 1302+	rare	B.T. Watson, W.C. Starnes
991011.5btw	10/11/1999	Broad	Rutherford	Cove Creek	SR 1337-	uncommon	B.T. Watson, W.C. Starnes
991026.3btw	10/26/1999	Broad	Polk	Machine Creek	SR 1330-	rare	B.T. Watson
991027.2btw	10/27/1999	Broad	Polk	Green River	SR 1151+/-	rare	B.T. Watson, W.C. Starnes
991027.5btw	10/27/1999	Broad	Rutherford	Broad River	SR 1181+	common	B.T. Watson, W.C. Starnes
<i><u>Notropis lutipinnis</u></i>							
990811.1btw	8/11/1999	Broad	Polk	Green River	SR 1151-	common	B.T. Watson, W.C. Starnes
990811.2btw	8/11/1999	Broad	Polk	Green River	SR 1151+/-	uncommon	B.T. Watson, W.C. Starnes
990811.3btw	8/11/1999	Broad	Polk	Cove Creek	SR 1151+/-	uncommon	B.T. Watson, W.C. Starnes
990812.3btw	8/12/1999	Broad	Polk	Gadd Creek	SR 1151-	present	B.T. Watson
990813.2btw	8/13/1999	Broad	Polk	Ostin Creek	SR 1142+/-	present	B.T. Watson
990813.3btw	8/13/1999	Broad	Polk	Silver Creek	SR 1138+/-	present	B.T. Watson
990830.2btw	8/30/1999	Broad	Polk	Wheat Creek	SR 1329+	present	B.T. Watson
990831.1btw	8/31/1999	Broad	Polk	White Oak Creek	SR 1005-	uncommon	B.T. Watson
990831.2btw	8/31/1999	Broad	Polk	Green Creek	SR 1340+	abundant	B.T. Watson
990831.4btw	8/31/1999	Broad	Rutherford	Cleghorn Creek	SR 1149-	uncommon	B.T. Watson

Table 5b (cont.). Freshwater fish species found in Green River Game Land and associated waterways.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Notropis lutipinnis</i>							
990831.5bw	8/31/1999	Broad	Polk	Mill Creek	SR 1339-	common	B.T. Watson
990908.3bw	9/8/1999	Broad	Rutherford	Knob Creek	US 64-74A+	present	B.T. Watson
990908.4bw	9/8/1999	Broad	Rutherford	West Branch (Mountain Creek)	SR 1351+	present	B.T. Watson
990909.1bw	9/9/1999	Broad	Polk	White Oak Creek	SR 1526-	present	B.T. Watson
990909.5bw	9/9/1999	Broad	Polk	Walnut Creek	SR 1311-	present	B.T. Watson
990910.1bw	9/10/1999	Broad	Rutherford	Billis Creek	SR 1008+/-	present	B.T. Watson
990910.3bw	9/10/1999	Broad	Rutherford	Cedar Creek	SR 1008+	present	B.T. Watson
990910.4bw	9/10/1999	Broad	Rutherford	East Branch (Mountain Creek)	SR 1331-	present	B.T. Watson
990914.1bw	9/14/1999	Broad	Rutherford	Cathays Creek	SR 1325+	present	B.T. Watson
990914.2bw	9/14/1999	Broad	Rutherford	Holland Creek	SR 1538-	present	B.T. Watson
990914.3bw	9/14/1999	Broad	Rutherford	Richardson Creek	SR 1135+	present	B.T. Watson
990914.4bw	9/14/1999	Broad	Rutherford/Polk	Henson Creek	SR 1300-	present	B.T. Watson
990915.5bw	9/15/1999	Broad	Henderson	Camp Creek	SR 1836+/-	present	B.T. Watson
990920.1bw	9/20/1999	Broad	Rutherford	Floyd's Creek	SR 2152-	present	B.T. Watson
990921.4bw	9/21/1999	Broad	Polk	North Pacolet River	US 176-	present	B.T. Watson
990921.5bw	9/21/1999	Broad	Polk	North Pacolet River	US 176 @ SR 1125+/-	present	B.T. Watson
990921.6bw	9/21/1999	Broad	Polk	Skyuka Creek	SR 1135-	uncommon	B.T. Watson
990922.1bw	9/22/1999	Broad	Polk	Britten Creek	SR 1158+/-	present	B.T. Watson
990922.4bw	9/22/1999	Broad	Rutherford	Second Broad River	SR 1602-	present	B.T. Watson
991011.1bw	10/11/1999	Broad	Rutherford	Second Broad River	SR 1602-	uncommon	B.T. Watson
991011.2bw	10/11/1999	Broad	Rutherford	East Branch (Mountain Creek)	SR 1331-	uncommon	B.T. Watson
991011.3bw	10/11/1999	Broad	Rutherford	West Branch (Mountain Creek)	SR 1351+	uncommon	B.T. Watson
991011.4bw	10/11/1999	Broad	Rutherford	Knob Creek	US 64-74A+	common	B.T. Watson
991011.5bw	10/11/1999	Broad	Rutherford	Cove Creek	SR 1337-	common	B.T. Watson
991011.6bw	10/11/1999	Broad	Rutherford	Cedar Creek	SR 1008-	common	B.T. Watson
991012.5bw	10/12/1999	Broad	Polk	North Pacolet River	US 176 @ SR 1125+/-	uncommon	B.T. Watson
991026.1bw	10/26/1999	Broad	Rutherford	Floyd's Creek	SR 2152+	common	B.T. Watson
991026.2bw	10/26/1999	Broad	Rutherford	Richardson Creek	SR 1135-	common	B.T. Watson
991026.3bw	10/26/1999	Broad	Polk	Machine Creek	SR 1330-	common	B.T. Watson
991027.2bw	10/27/1999	Broad	Polk	Green River	SR 1151+/-	rare	B.T. Watson
991027.3bw	10/27/1999	Broad	Polk	Ostin Creek	SR 1142+	common	B.T. Watson
991027.4bw	10/27/1999	Broad	Polk	Walnut Creek	SR 1311-	abundant	B.T. Watson

Table 5b (cont.). Freshwater fish species found in Green River Game Land and associated waterways.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Notropis rubricroceus</i>							
990915.2btw	9/15/1999	Broad	Henderson	Joe Creek	SR 1106+	present	B.T. Watson
991012.2btw	10/12/1999	Broad	Henderson	Green River	SR 1104+	uncommon	B.T. Watson
991012.3btw	10/12/1999	Broad	Henderson	Rock Creek	SR 1106-	common	B.T. Watson
991012.4btw	10/12/1999	Broad	Henderson	Joe Creek	SR 1106-	abundant	B.T. Watson
991027.1btw	10/27/1999	Broad	Henderson	Big Hungry River	SR 1802-/+	patchy common	B.T. Watson
<i>Notropis scepticus</i>							
990830.1btw	8/30/1999	Broad	Polk	Green River	SR 1331+	present	B.T. Watson
990922.3btw	9/22/1999	Broad	Rutherford	Broad River	US 64-74A @ SR1184-	common	B.T. Watson, W.C. Starnes
990922.4btw	9/22/1999	Broad	Rutherford	Second Broad River	SR 1602-	present	B.T. Watson, W.C. Starnes
990923.2btw	9/23/1999	Broad	Polk	Green River	SR 1331-/+	uncommon	B.T. Watson, W.C. Starnes
990923.3btw	9/23/1999	Broad	Polk	Green River	SR 1302+	rare	B.T. Watson, W.C. Starnes
990923.4btw	9/23/1999	Broad	Polk	Green River	SR 1313+	common	B.T. Watson, W.C. Starnes
991011.5btw	10/11/1999	Broad	Rutherford	Cove Creek	SR 1337-	uncommon	B.T. Watson, W.C. Starnes
991027.5btw	10/27/1999	Broad	Rutherford	Broad River	SR 1181+	uncommon	B.T. Watson, W.C. Starnes
<i>Notropis sp.</i>							
990909.6btw	9/9/1999	Broad	Rutherford	Broad River	SR 1181+	present	B.T. Watson
990910.2btw	9/10/1999	Broad	Rutherford	Cove Creek	SR 1337-	present	B.T. Watson
<i>Notropis spectrunculus</i>							
990811.1btw	8/11/1999	Broad	Polk	Green River	SR 1151-	uncommon	B.T. Watson, W.C. Starnes
990812.1btw	8/12/1999	Broad	Polk	Green River	SR 1151-	uncommon	B.T. Watson
991012.3btw	10/12/1999	Broad	Henderson	Rock Creek	SR 1106-	rare	B.T. Watson
<i>Notropis spp.</i>							
990831.3btw	8/31/1999	Broad	Polk	Green River	SR 1302+	present	B.T. Watson
990902.1btw	9/2/1999	Broad	Polk	Green River	SR 1005 -/+	present	B.T. Watson
990902.2btw	9/2/1999	Broad	Polk	Broad River	SR 1155-/+	present	B.T. Watson
<i>Noturus insignis</i>							
990811.1btw	8/11/1999	Broad	Polk	Green River	SR 1151-	common	B.T. Watson
990811.2btw	8/11/1999	Broad	Polk	Green River	SR 1151-/+	uncommon	B.T. Watson
990811.3btw	8/11/1999	Broad	Polk	Cove Creek	SR 1151-/+	common	B.T. Watson
990812.1btw	8/12/1999	Broad	Polk	Green River	SR 1151-	uncommon	B.T. Watson

Table 5b (cont.). Freshwater fish species found in Green River Game Land and associated waterways.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Noturus insignis</i>							
990813.4bw	8/13/1999	Broad	Polk	Green River	SR 1313+	common	B.T. Watson
990830.1bw	8/30/1999	Broad	Polk	Green River	SR 1331+	present	B.T. Watson
990831.1bw	8/31/1999	Broad	Polk	White Oak Creek	SR 1005-	rare	B.T. Watson
990831.5bw	8/31/1999	Broad	Polk	Mill Creek	SR 1339-	rare	B.T. Watson
990901.1bw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
990901.2bw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
990902.1bw	9/2/1999	Broad	Polk	Green River	SR 1005-/+	present	B.T. Watson
990902.2bw	9/2/1999	Broad	Polk	Mountain Creek	SR 1155-/+	present	B.T. Watson
990908.1bw	9/8/1999	Broad	Rutherford	Broad River	NC 108-/+	present	B.T. Watson
990908.4bw	9/8/1999	Broad	Rutherford	West Branch (Mountain Creek)	SR 1351+	present	B.T. Watson
990909.5bw	9/9/1999	Broad	Polk	Walnut Creek	SR 1311-	present	B.T. Watson
990909.6bw	9/9/1999	Broad	Rutherford	Broad River	SR 1181+	present	B.T. Watson
990910.2bw	9/10/1999	Broad	Rutherford	Cove Creek	SR 1337-	present	B.T. Watson
990910.3bw	9/10/1999	Broad	Rutherford	Cedar Creek	SR 1008+	present	B.T. Watson
990921.5bw	9/21/1999	Broad	Polk	North Paolet River	US 176 @ SR 1125-/+	present	B.T. Watson
990921.6bw	9/21/1999	Broad	Polk	Skyuka Creek	SR 1135-	present	B.T. Watson
990922.3bw	9/22/1999	Broad	Rutherford	Broad River	US 64-74A @ SR 1184-	common	B.T. Watson
990923.1bw	9/23/1999	Broad	Rutherford	Broad River	SR 1155-	uncommon	B.T. Watson
990923.2bw	9/23/1999	Broad	Polk	Green River	SR 1331-/+	rare	B.T. Watson
990923.3bw	9/23/1999	Broad	Polk	Green River	SR 1302+	uncommon	B.T. Watson
990923.4bw	9/23/1999	Broad	Polk	Green River	SR 1313+	uncommon	B.T. Watson
991011.5bw	10/11/1999	Broad	Rutherford	Cove Creek	SR 1337-	uncommon	B.T. Watson
991011.6bw	10/11/1999	Broad	Rutherford	Cedar Creek	SR 1008-	rare	B.T. Watson
991012.5bw	10/12/1999	Broad	Polk	North Paolet River	US 176 @ SR 1125-/+	uncommon	B.T. Watson
991026.3bw	10/26/1999	Broad	Polk	Machine Creek	SR 1330-	rare	B.T. Watson
991027.2bw	10/27/1999	Broad	Polk	Green River	SR 1151-/+	common	B.T. Watson
991027.5bw	10/27/1999	Broad	Rutherford	Broad River	SR 1181+	uncommon	B.T. Watson
<i>Oncorhynchus mykiss</i>							
990811.1bw	8/11/1999	Broad	Polk	Green River	SR 1151-	rare	B.T. Watson
990811.2bw	8/11/1999	Broad	Polk	Green River	SR 1151-/+	rare	B.T. Watson
990811.3bw	8/11/1999	Broad	Polk	Cove Creek	SR 1151-/+	rare	B.T. Watson
990813.1bw	8/13/1999	Broad	Polk	Cove Creek	SR 1142+	present	B.T. Watson
990915.4bw	9/15/1999	Broad	Henderson	Tributary to Green River	US 176 (beside)+	present	B.T. Watson
990921.1bw	9/21/1999	Broad	Henderson	Green River	SR 1104+	present	B.T. Watson

Table 5b (cont.). Freshwater fish species found in Green River Game Land and associated waterways.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Oncorhynchus mykiss</i>							
990921.3bw	9/21/1999	Broad	Henderson	Bob's Creek	SR 1101 @ SR 1104-	present	B.T. Watson
990921.4bw	9/21/1999	Broad	Polk	North Paoclet River	US 176-	present	B.T. Watson
990921.5bw	9/21/1999	Broad	Polk	North Paoclet River	US 176 @ SR 1125-/+	present	B.T. Watson
991012.3bw	10/12/1999	Broad	Henderson	Rock Creek	SR 1106-	uncommon	B.T. Watson
991012.5bw	10/12/1999	Broad	Polk	North Paoclet River	US 176 @ SR 1125-/+	rare	B.T. Watson
991027.1bw	10/27/1999	Broad	Henderson	Big Hungry River	SR 1802-/+	rare	B.T. Watson
<i>Percina crassa</i>							
990811.1bw	8/11/1999	Broad	Polk	Green River	SR 1151-	common	B.T. Watson, W.C. Starnes
990811.2bw	8/11/1999	Broad	Polk	Green River	SR 1151-/+	uncommon	B.T. Watson, W.C. Starnes
990811.3bw	8/11/1999	Broad	Polk	Cove Creek	SR 1151-/+	uncommon	B.T. Watson
990812.1bw	8/12/1999	Broad	Polk	Green River	SR 1151-	common	B.T. Watson
990813.4bw	8/13/1999	Broad	Polk	Green River	SR 1313+	present	B.T. Watson
990830.1bw	8/30/1999	Broad	Polk	Green River	SR 1331+	present	B.T. Watson
990901.1bw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
990901.2bw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson
990902.1bw	9/2/1999	Broad	Polk	Green River	SR 1005 -/+	present	B.T. Watson
990902.2bw	9/2/1999	Broad	Polk	Broad River	SR 1155-/+	present	B.T. Watson
990909.6bw	9/9/1999	Broad	Rutherford	Broad River	SR 1181+	present	B.T. Watson
990910.2bw	9/10/1999	Broad	Rutherford	Cove Creek	SR 1337-	present	B.T. Watson
990922.3bw	9/22/1999	Broad	Rutherford	Broad River	US 64-74A @ SR 1184-	rare	B.T. Watson
990923.1bw	9/23/1999	Broad	Rutherford	Broad River	SR 1155-	rare	B.T. Watson
990923.2bw	9/23/1999	Broad	Polk	Green River	SR 1331-/+	rare	B.T. Watson
990923.3bw	9/23/1999	Broad	Polk	Green River	SR 1302+	rare	B.T. Watson
990923.4bw	9/23/1999	Broad	Polk	Green River	SR 1313+	uncommon	B.T. Watson
991027.2bw	10/27/1999	Broad	Polk	Green River	SR 1151-/+	rare	B.T. Watson
<i>Pylodictis olivaris</i>							
990811.2bw	8/11/1999	Broad	Polk	Green River	SR 1151-/+	present (visual)	B.T. Watson
<i>Rhinichthys atratulus</i>							
990811.3bw	8/11/1999	Broad	Polk	Cove Creek	SR 1151-/+	rare	B.T. Watson
990915.3bw	9/15/1999	Broad	Henderson	Freeman Creek	by SR 1115-/+	common	B.T. Watson, W.C. Starnes
990915.4bw	9/15/1999	Broad	Henderson	Tributary to Green River	US 176 (beside)+	present	B.T. Watson
990915.5bw	9/15/1999	Broad	Henderson	Camp Creek	SR 1836-/+	present	B.T. Watson

Table 5b (cont.). Freshwater fish species found in Green River Game Land and associated waterways.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Rhinichthys atratulus</i>							
990921.3bw	9/21/1999	Broad	Henderson	Bob's Creek	SR 1101 @ SR 1104-	present	B.T. Watson
990921.4bw	9/21/1999	Broad	Polk	North Pacolet River	US 176-	present	B.T. Watson
990922.5bw	9/22/1999	Broad	Henderson	Little Hungry River	SR 1713+	abundant	B.T. Watson
990922.6bw	9/22/1999	Broad	Henderson	Big Hungry River	SR 1802-/+	present	B.T. Watson
991012.4bw	10/12/1999	Broad	Henderson	Joe Creek	SR 1106-	rare	B.T. Watson
991027.1bw	10/27/1999	Broad	Henderson	Big Hungry River	SR 1802-/+	common	B.T. Watson
<i>Salvelinus fontinalis</i>							
990811.1bw	8/11/1999	Broad	Polk	Green River	SR 1151-	rare	B.T. Watson
<i>Scartomyzon rupiscartes</i>							
990811.1bw	8/11/1999	Broad	Polk	Green River	SR 1151-	abundant	B.T. Watson, W.C. Starnes
990811.2bw	8/11/1999	Broad	Polk	Green River	SR 1151-/+	rare	B.T. Watson
990921.4bw	9/21/1999	Broad	Polk	North Pacolet River	US 176-	patchy rare	B.T. Watson, W.C. Starnes
990921.5bw	9/21/1999	Broad	Polk	North Pacolet River	US 176 @ SR 1125-/+	common	B.T. Watson
990921.6bw	9/21/1999	Broad	Polk	Skyuka Creek	SR 1135-	present	B.T. Watson
990922.2bw	9/22/1999	Broad	Polk	Unnamed tributary to Lake Adger	SR 1156-/+	present	B.T. Watson
991012.5bw	10/12/1999	Broad	Polk	North Pacolet River	US 176 @ SR 1125-/+	abundant	B.T. Watson, W.C. Starnes
991027.3bw	10/27/1999	Broad	Polk	Ostin Creek	SR 1142+	patchy common	B.T. Watson, W.C. Starnes
<i>Scartomyzon sp.</i>							
990811.3bw	8/11/1999	Broad	Polk	Cove Creek	SR 1151-/+	common	B.T. Watson, W.C. Starnes
990812.1bw	8/12/1999	Broad	Polk	Green River	SR 1151-	rare	B.T. Watson
990831.4bw	8/31/1999	Broad	Rutherford	Cleghorn Creek	SR 1149-	rare	B.T. Watson, W.C. Starnes
990923.1bw	9/23/1999	Broad	Rutherford	Broad River	SR 1155-	rare	B.T. Watson, W.C. Starnes
990923.2bw	9/23/1999	Broad	Polk	Green River	SR 1331-/+	rare	B.T. Watson, W.C. Starnes
991011.6bw	10/11/1999	Broad	Rutherford	Cedar Creek	SR 1008-	uncommon	B.T. Watson, W.C. Starnes
991027.1bw	10/27/1999	Broad	Henderson	Big Hungry River	SR 1802-/+	rare	B.T. Watson, W.C. Starnes
991027.2bw	10/27/1999	Broad	Polk	Green River	SR 1151-/+	rare	B.T. Watson, W.C. Starnes
<i>Scartomyzon sp./Moxostoma sp.</i>							
990831.1bw	8/31/1999	Broad	Polk	White Oak Creek	SR 1005-	rare	B.T. Watson
990831.2bw	8/31/1999	Broad	Polk	Green Creek	SR 1340+	rare	B.T. Watson
990831.5bw	8/31/1999	Broad	Polk	Mill Creek	SR 1339-	uncommon	B.T. Watson
990901.1bw	9/1/1999	Broad	Polk	Green River	SR 1151+	present	B.T. Watson

Table 5b (cont.). Freshwater fish species found in Green River Game Land and associated waterways.

Site No.	Date	River Basin	County	Waterway	Road No.	Abundance	Identified By
<i>Scartomyzon</i> sp./ <i>Moxostoma</i> sp.							
990909.6btw	9/9/1999	Broad	Rutherford	Broad River	SR 1181+	present	B.T. Watson
990923.3btw	9/23/1999	Broad	Polk	Green River	SR 1302+	rare	B.T. Watson
990923.4btw	9/23/1999	Broad	Polk	Green River	SR 1313+	rare	B.T. Watson
991011.1btw	10/11/1999	Broad	Rutherford	Second Broad River	SR 1602-	uncommon	B.T. Watson
991011.2btw	10/11/1999	Broad	Rutherford	East Branch (Mountain Creek)	SR 1331-	rare	B.T. Watson
991011.4btw	10/11/1999	Broad	Rutherford	Knob Creek	US 64-74A	rare	B.T. Watson
991011.5btw	10/11/1999	Broad	Rutherford	Cove Creek	SR 1337-	uncommon	B.T. Watson
991012.3btw	10/12/1999	Broad	Henderson	Rock Creek	SR 1106-	rare	B.T. Watson
991026.1btw	10/26/1999	Broad	Rutherford	Floyd's Creek	SR 2152+	uncommon	B.T. Watson
991026.3btw	10/26/1999	Broad	Polk	Machine Creek	SR 1330-	common	B.T. Watson
991026.4btw	10/26/1999	Broad	Polk	White Oak Creek	SR 1526-	common	B.T. Watson
<i>Semotilus atromaculatus</i>							
990811.1btw	8/1/1999	Broad	Polk	Green River	SR 1151-	rare	B.T. Watson
990813.1btw	8/13/1999	Broad	Polk	Cove Creek	SR 1142+	present	B.T. Watson
990813.2btw	8/13/1999	Broad	Polk	Osin Creek	SR 1142-/+	present	B.T. Watson
990813.3btw	8/13/1999	Broad	Polk	Silver Creek	SR 1138-/+	present	B.T. Watson
990830.2btw	8/30/1999	Broad	Polk	Wheat Creek	SR 1329+	present	B.T. Watson
990831.1btw	8/31/1999	Broad	Polk	White Oak Creek	SR 1005-	rare	B.T. Watson
990831.2btw	8/31/1999	Broad	Polk	Green Creek	SR 1340+	rare	B.T. Watson
990831.4btw	8/31/1999	Broad	Rutherford	Cleghorn Creek	SR 1149-	rare	B.T. Watson
990831.5btw	8/31/1999	Broad	Polk	Mill Creek	SR 1339-	rare	B.T. Watson
990908.2btw	9/8/1999	Broad	Rutherford	Maple Creek	by SR 1178 -/+	present	B.T. Watson
990909.3btw	9/9/1999	Broad	Polk	Little White Oak Creek	SR 1322+	present	B.T. Watson
990921.4btw	9/21/1999	Broad	Polk	North Pacolet River	US 176-	present	B.T. Watson
990922.1btw	9/22/1999	Broad	Polk	Britten Creek	SR 1158-/+	present	B.T. Watson
990922.2btw	9/22/1999	Broad	Polk	Unnamed tributary to Lake Adger	SR 1156-/+	present	B.T. Watson
990922.4btw	9/22/1999	Broad	Rutherford	Second Broad River	SR 1602-	present	B.T. Watson
990922.6btw	9/22/1999	Broad	Henderson	Big Hungry River	SR 1802-/+	present	B.T. Watson
991011.1btw	10/11/1999	Broad	Rutherford	Second Broad River	SR 1602-	uncommon	B.T. Watson
991011.2btw	10/11/1999	Broad	Rutherford	East Branch (Mountain Creek)	SR 1331-	common	B.T. Watson
991011.5btw	10/11/1999	Broad	Rutherford	Cove Creek	SR 1337-	rare	B.T. Watson
991011.6btw	10/11/1999	Broad	Rutherford	Cedar Creek	SR 1008-	uncommon	B.T. Watson
991012.2btw	10/12/1999	Broad	Henderson	Green River	SR 1104+	rare	B.T. Watson

Table 5b (cont.). Freshwater fish species found in Green River Game Land and associated waterways.

<u>Site No.</u>	<u>Date</u>	<u>River Basin</u>	<u>County</u>	<u>Waterway</u>	<u>Road No.</u>	<u>Abundance</u>	<u>Identified By</u>
<i>Semotilus atromaculatus</i>							
991026.2btw	10/26/1999	Broad	Rutherford	Richardson Creek	SR 1135-	rare	B.T. Watson
991026.3btw	10/26/1999	Broad	Polk	Machine Creek	SR 1330-	rare	B.T. Watson
991026.4btw	10/26/1999	Broad	Polk	White Oak Creek	SR 1526-	common	B.T. Watson
991027.1btw	10/27/1999	Broad	Henderson	Big Hungry River	SR 1802-/+	patchy common	B.T. Watson
991027.3btw	10/27/1999	Broad	Polk	Ostin Creek	SR 1142+	common	B.T. Watson

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